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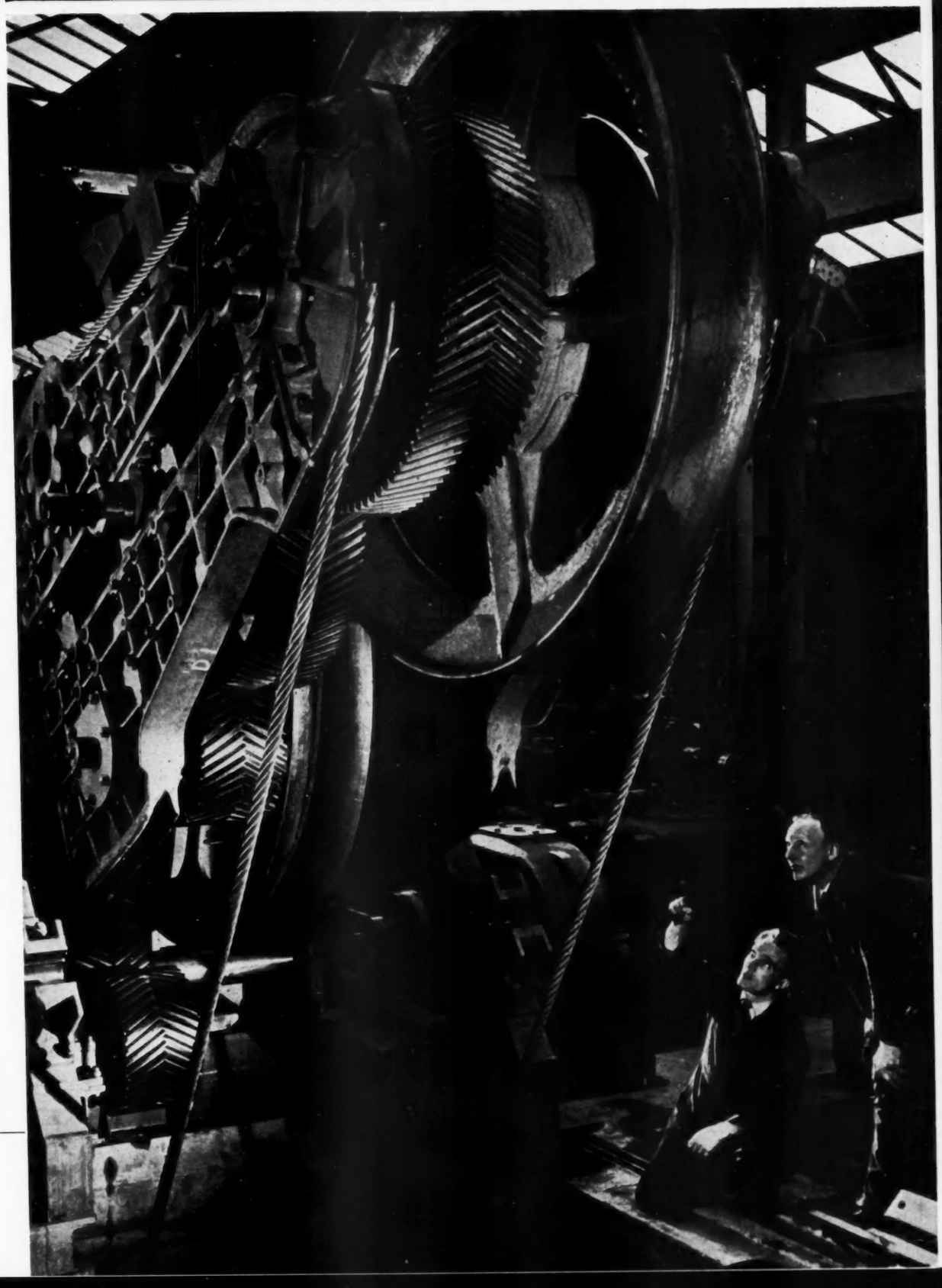
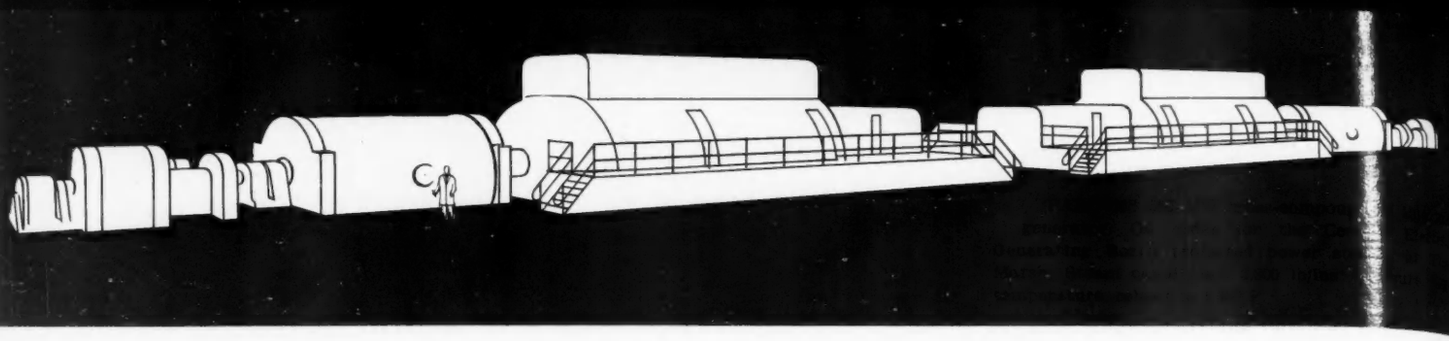
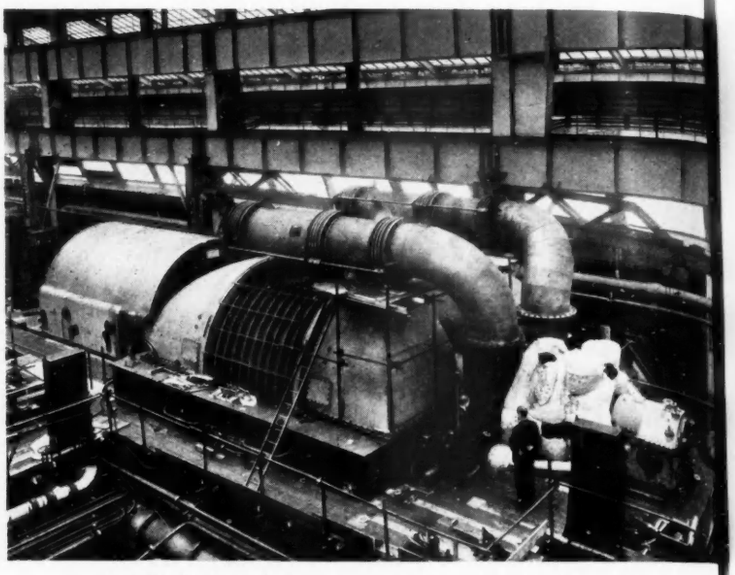


ble-Laying Gear under Test

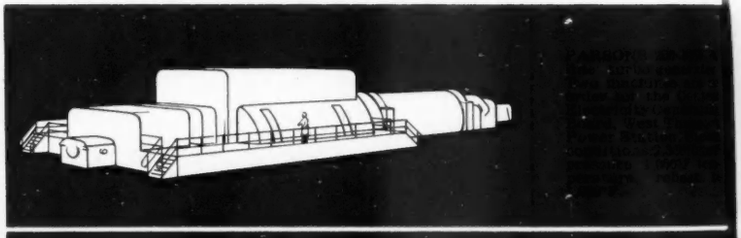


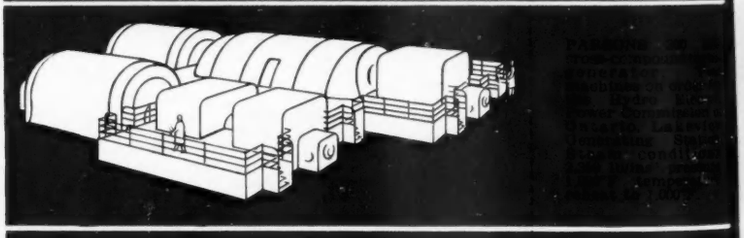
Increasing power output

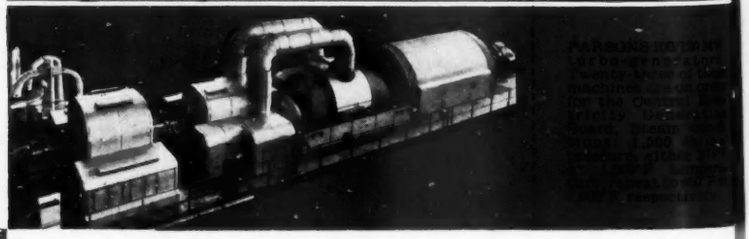
A significant development in the design of steam turbo-generators for power stations is the increase in the power output of individual machines. This is evident in the range of large turbo-generators now under construction at Heaton Works.



PARSONS 200 MW cross-compound turbo-generator (View of low pressure line only). Four of these machines are under construction for the Hydro Electric Power Commission of Ontario, Richard L. Hearn Generating Station. Steam conditions: 1,800 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.







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Solely Responsible?

"THEREFORE I hold Driver W. J. Trew solely responsible for this accident." That is the conclusion of the Chief Inspecting Officer of Railways in his report, published last week, on the accident at Lewisham in December, 1957. It is a simple and convenient explanation, in keeping with the traditional style of railway accident reports, but the time has come to question this traditional style. The time has come to take all such inquiries a stage further and ask not only who was directly responsible but why he behaved in that way. In the case of the Lewisham collision, why did Driver Trew pass three signals in succession, all at danger? Enough is known to-day about human behaviour—so often outwardly irrational—to make it worth-while studying these accidents. Indeed it is irresponsible to spend millions of pounds under the railway modernisation plan on signalling and train control improvements without having first learnt all that can be learnt from a scientific study of the behaviour of train crews. There would not then be the same readiness to say "I hold Driver W. J. Trew solely responsible."

To read such an accident report is to be aware of the futility of a procedure which assumes that the entire blame can and must be placed on an individual or several individuals—usually operators. The inspecting officer searches diligently for a rational explanation of irrational behaviour. Even the driver, or signalman—whoever it may be—follows the lead given by the inspecting officer and tries desperately to find a rational explanation for his own tragic behaviour. Such a procedure is humiliating and degrading; it implies that a man will deliberately, consciously and in full possession of his senses, risk his own life and the lives of others.

It may be convenient to dismiss complex reactions which lead to errors as due to individual carelessness or freakish inefficiency. But the dangers of this superficial approach have been evident since 1795 when Maskelyne, then Head of the Greenwich Observatory, discharged an assistant for alleged carelessness in recording the transit time of stars. The case caused a political stir at the time, and soon afterwards a more scientific approach was made by Donders. His experiments showed that the discrepancies in the reaction times of different observers were not due to carelessness, but to a basic human phenomenon, now widely known as the "personal equation." This definition of the real causes led, as it usually does, to satisfactory remedies. History may be repeating itself in the Lewisham accident report: a simple and convenient explanation of individual carelessness is unlikely to carry much conviction. At best the explanation is superficial and trivial, and at worst it may obscure the real issues and faults, and so delay corrective measures.

It would be less futile to consider some basic limitations of the human brain—limitations which are common to us all but which appeared as major factors in the lapse of Driver Trew. The brain can be compared with the information processing and transmission devices of communication engineering, and within limits the same mathematics can be applied. The brain has limited capacity in dealing with incoming information. There are no difficulties in dealing with messages which conform to expectancies since such information is largely "redundant." Grave difficulties arise, however, when the messages conflict with expectancies; the latter may persist for a considerable time, despite a great deal of contrary information. In everyday terms, we are creatures of habit who tend to run through a learnt sequence of actions, sometimes in inappropriate conditions, and this tendency to perseverate usually increases with advancing years. It is the unusual event which leads to the greatest confusion, uncertainty and delays.

There were several factors in the Lewisham accident which were clearly relevant to a full inquiry by people who have experience of the science of human behaviour, and no doubt others would be brought to light. The driver said he had never been stopped by that home signal before, i.e., it was contrary to his expectancy. In his report, the inspecting officer quotes two other accidents when steam locomotive drivers failed to respond to colour light signals—at Harrow in 1952 and at Ilford in 1944. It may be significant that all three accidents occurred in fog or mist. In a year, British Railways run about 380 million train-miles; depending on the average spacing of signals, their drivers must pass many millions of signals. Driver Trew had probably observed a million or more signals in the course of his 18 years' experience as a driver. It is high time for the inquiry services of the Ministry of Transport, which have contributed so much to the safety of railways, to be augmented by a team of people who can analyse and define the real causes of such accidents. The knowledge so gained can then be applied by the British Transport Commission to the design of signalling and train control systems.

Cover Picture. *The development of the flexible repeater has been a great advance for submarine telephone cables. It has also meant some modifications to the laying gear, as the minimum radius to which the repeater can be bent is strictly limited. The strains imposed are still severe and the illustration shows part of a ship's laying gear undergoing test.*

(*Nurnberg photograph for* ENGINEERING)

* * *

Plain Words

I am signalling frantically this week! The wisp of smoke which has put me on the alert is a sentence in the annual report of the Council of Industrial Design. It reads: " there is still much to be done in providing trained industrial designers especially for the engineering industries." For the benefit of overseas readers who may not appreciate the difference, I should explain that an industrial designer is to an engineering designer as an architect is to a structural engineer: one thinks of appearance first, the other of function. I ought to explain, too, that the Council of Industrial Design is an admirable organisation which was set up in December, 1944, by the President of the Board of Trade " to promote by all practicable means the improvement of design in the products of British industry."

So far, the Council has given most attention to consumer goods. It has done a lot to encourage the development of good design; but " good design " from what I would call—without being offensive—the lay man's point of view: which means good to look at and good to use. Now you may say that that surely is everything. So it is, but when we say " good to look at " we immediately raise the question " Who's doing the looking? " If we are considering say a spoon, then I suppose an engineer's opinion is no more valuable than a housewife's—probably a good deal less. But if we go to a vacuum cleaner, or a washing machine, then I think an engineer's opinion is worth having. How a product is made inevitably affects its efficiency in use. In the case of any reasonable spoon the effect is small; in the case of a washing machine the effect is considerable. We might state a general law, thus: the more the function of a product is susceptible to engineering analysis, the more its appearance is a natural consequence of its functional design.

The Council is fully alive to the dangers of allowing industrial designers, with no engineering knowledge, to dabble in the appearance design of engineering products, but are all engineering designers alive to the importance of appearance where appearance is not wholly a consequence of the functional design? I doubt it. My frantic signal, therefore, is not to arouse engineering designers to impending attack, but to signal them that a small Long Range Design Group is setting out to help them. And if they ignore the Group it will sooner or later dominate the field. If that seems far-fetched, consider for a moment the position of the architect in relation to the structural engineer.

CAPRICORN

Weekly Survey

Planning for What?

The pamphlet *Plan for Progress*, put out by the Labour Party, has all the marks of compromise between socialist theory and Labour Party practical politics. It has something in it for everybody who has an urge to vote socialist.

The basic assertion is that an expanding economic policy, full employment, stable prices, and a strong pound are quite reconcilable in a planned economy. The pamphlet emphasises that planning does not mean detailed control but is concerned with the larger decisions of how to match savings with investment, exports with imports and spending with output. At the top of the priority list for the next Labour Government are the strength of the pound and a maintained high level of investment in industry. Tax methods will be used, with such devices as variations in investment allowances, to increase the speed of writing off of capital equipment; and the Government will also use taxation methods to raise the level of savings to cover the expanding rate of investment. Building licences will be used as a strategic control over industrial investment and a National Investment Board will be established to keep the investment policies of companies under review. Planning investment by industry will involve accelerating and retarding the investment programmes of the big public companies as well as State corporations—surely a difficult thing to do without detailed control.

Wage restraint is handled with extreme care. No kind of wage freeze is envisaged but the growth of money incomes will be kept in step with higher productivity, taking the national economy as a whole. The authors are of the opinion that the kind of economic policy which the Labour Government will carry out will be able to rely on the goodwill and co-operation of the trade union movement.

The assumptions on which the Labour Party's economic policy is based are no more demonstrably practicable than those of the present Government. The Party assume that no order of priority is necessary in a partially planned economy between full employment, a strong pound, a high rate of investment, and inflation. They also assume that the trade unions will be content to exact only a limited share of the national product. On experience since the war, no matter which party has been in power, neither of these assumptions has been realised.

European Markets Data

A new research organisation, Analytical European Surveys Limited (A.E.S.), has been launched by two of the leading British and international advertising agents—S. H. Benson Limited and Colman Prentis & Varley Limited—in association with a Swiss company, Analyses Economiques et Sociales (A.E.S.), of Lausanne. The Swiss company already provide marketing information based on the statistical analysis of field interviews to a large number of manufacturers in Switzerland. The British company's main purpose is to bring the services of the new organisation within easy reach of English-speaking manufacturers, but it will also make available the services of distinguished academic people such as Professor Richard Stone, Leake Professor of finance and accounting, Cambridge University; Professor Maurice Kendall, professor of statistics, London University; and Dr. Robert Andry, senior clinical psychologist at several hospitals.

In a brochure entitled " Western Europe," A.E.S. give some salient facts about the market and emphasise its complexity, pointing out that in the past " it has been far from easy to obtain up-to-the-minute facts and figures tailored to suit individual requirements." They will provide information on the structure of the market, consumer preferences and local purchasing habits. They will use statistical sources, both published and unpublished, and carry out original field work among manufacturers, wholesalers, retailers or consumers. There is a great deal to be done, if only to remove the fears and misconceptions concerning the markets of Europe that have built up in British industry since the war, and to point out the opportunities that exist.

Italy's New Government

Although Italy has the largest Communist Party west of the Iron Curtain it continues to be governed by coalitions controlled by the right wing Christian Democrats. The recent general election has not greatly altered party strengths but it has nevertheless brought one very important change. Italy now has in Signor Amintore Fanfani a new prime minister with a reputation for getting things done. Fanfani has been minister of labour and of agriculture in earlier post-war governments, and in 1954 he almost became prime minister when de Gaspari retired. Now he has his chance to implement the reforms outlined in his election programme. He has taken an early opportunity of assuring other Western European governments that Italy will continue to support the European Common Market and Euratom projects. Italian industry has been given a promise that the present out-of-date tax system will be reformed.

The long shadow of the American recession has fallen on the Fanfani programme to the extent of securing the setting up of a permanent Projects Committee. This body has the task of preparing plans for public works and development projects now, so that these can be put into action immediately should they be needed. A fund of a billion lire has been allocated to this purpose.

Another important change of policy is foreshadowed in connection with the state-controlled industries. At present these are all grouped under I.R.I. the official holding company, except for the oil and natural gas concerns which are controlled by the E.N.I. agency. Signor Fanfani proposes to bring the state-controlled electricity generating companies now in the I.R.I. group into E.N.I. This would have the effect of giving E.N.I. responsibility for all forms of energy production. This move is seen as a first step towards the nationalisation of all Italian electricity generating companies. The somewhat cumbersome committee structure of I.R.I. is to be streamlined and it is probable that the new government will be looking for other ways of increasing the efficiency of what has up to now been the least progressive sector of Italian industry. Increased spending on the welfare services is also forecast and a stepping up of activity by the Casa per il Mezzogiorno, the Government-sponsored development agency for the poverty-stricken South. All told it looks as though Signor Fanfani intends to follow policies of the left although drawing his main support from the right.

Slight Progress on the F.T.A.

Last week's meeting in Paris on the Free Trade Area turned out to be less of a crisis than had been expected. Both the British and the French have modified their attitudes slightly, but without significantly changing their positions. On the one hand, the French have shown a willingness to discuss their free-trade apprehensions in specific terms. On the other, the British have stopped insisting that agreement must be reached before the end of the year when the first reductions in tariffs are due to take effect within the European Common Market.

It seems that the members of the European Economic Community and the probable members of the F.T.A. are moving towards the position when there will be a 10 per cent cut in tariffs all round next January. This means that negotiations on the F.T.A. will continue during the autumn. Little more was said on the subject by Mr. Reginald Maudling, the Minister in charge of the F.T.A. negotiations in this country, in a statement on his return, made in the House of Commons at the end of last week.

The main progress made in the early sessions of the meetings last week was agreement to tackle the problem of definition of origin of goods sector by sector. This development probably means that the ultimate solution to the problem will be a combination of certificates of origin, the Carli proposals on compensatory import duties, and the harmonisation of external tariffs.

Brazilian Ventures

In spite of balance-of-payment difficulties and internal inflation, the Kubitschek régime is making a determined effort to expand Brazilian industrial capacity, and it is hoped that the Middle East situation will induce foreign industrialists to show increasing interest in that country. Industrial expansion is being financed largely by dollar loans and by a system under which foreign investment in Brazilian industry is permitted in the form of imports of machinery. Such imports are given a nominal value and then written up as the capital investment of the foreign firm concerned in its Brazilian subsidiary or associated company. In the first quarter of 1958, some 30 foreign organisations invested about 15 million dol in this way, and, in the whole of 1957, the number of investors was 239.

The system has been in operation for three years, and during this period a total of 218 million dol has been invested, of which about half was accounted for by United States concerns. German manufacturers invested 29 million dol, Swiss 22 million dol, British 9·7 million dol, French about 8 million dol, and Japanese about 7 million dol. Most of the industry established has been designed to supply the Brazilian home market but, in some instances, export activities are now being developed. A case in point in the engineering field is sewing machines, of which some 10,000 items, valued at about half-a-million dol are to be exported in 1958 to the United States. This year, Brazil is also exporting bicycles, domestic electric appliances, refrigerators, lifts and weighing machines, while the motor industry, of course, is expanding to supply the home market. Heavy engineering equipment is to be made in a new plant belonging to Mecanica Perada at Taubate, Sao Paulo, in which the Schneider Group is the leading foreign interest. At the same time, Brown Boveri is increasing the output of heavy electrical equipment at a factory near Sao Paulo, and there is also a well-developed industry for the production of railway coaches.

One of the main factors limiting expansion of the engineering industries is inadequate steel capacity, although the production of this material reached 1·4 million tons in 1956 and is expected to exceed 2 million tons by 1960. Further expansion plans provide for an output of about 4 million tons by 1965, but it is feared that the actual figures may not exceed 3 million tons, which would fall short of the estimated demand of 3½ million tons. There is clearly scope for considerable expansion of investment by the British engineering industry in Brazil, and this country's previous unfortunate experience of investing in South America should not be allowed to prevent this expansion.

Slipped

The shipbuilding industry, with orders in hand valued at £860 million, equivalent to about four years' work at current rates of output, might be expected to have few worries for the future. Yet the recently-published figures of the Shipbuilding Conference for new orders and cancellations during the first six months of this year must give rise to anxiety regarding the long-term position of the industry. Orders cancelled in the first six months of this year amounted to 283,000 tons and, early in July, it was announced that the P. and O. Group had cancelled an order for a 37,000 ton tanker. Against this, new orders received in the first half of the year totalled only 104,000 tons. For the twelve months ended June last, cancellations amounted to 382,000 tons and new orders to 593,000 tons, a net influx of only 209,000 tons of new orders, which compares with an average rate of construction of about 1·4 million tons in each of the last three years.

Having regard to the fact that, at the present time, over 1 million tons of British shipping is laid up owing to declining world trade and low freight rates, the volume of cancellations is not high, but fears have been expressed that any further rise in shipbuilding costs might cause a substantial increase in cancelled orders. In any case, the United Kingdom shipbuilding industry is better placed than that of most of her foreign competitors. In Japan, for example, the first six months of this year saw a big fall in tonnage under construction, from 1,588,280 tons to 1,255,563 tons, and the tonnage commenced during the three months ended June last, amounting to 495,470 tons, was the lowest since the first half of 1956. It has been estimated that if world trade could be restored to the level of mid-1957 world replacement, the demand for ships would probably amount to about 5 million tons per annum. Compared with the rate of launchings in 1957, this indicates the probability of a considerable surplus shipyard capacity. The British shipbuilding industry must accordingly utilise the breathing space provided by the present volume of orders in hand to ensure that it is fully competitive with foreign builders.

Aluminium Dumping

The aluminium industry, in contrast to producers of other non-ferrous metals, has hitherto been successful in maintaining relatively stable prices. During the past year, however, offers of metal at low prices from behind the Iron Curtain have been one of the factors causing weakness in the world price structure. The effect of these offers, however, would have been much less pronounced if declining world consumption had not led to the existence of surplus capacity. Last week, for example, Aluminium Limited, the major Canadian producer, announced a 10 per cent cut in production from the beginning of August, when output will be about 72 per cent of installed smelter capacity.

As early as January of this year, Aluminium Union Limited made an application to the Board of Trade for an anti-dumping duty designed to exclude from the British market the cheap aluminium on offer from Russia and the satellite countries, but no final decision has yet been taken. It is understood that the majority of consumers were willing to accept such a duty in order to achieve the traditional supply pattern and stability of the industry. There are, of course, a number of difficulties in the way of granting any such duty. Apart from the political implications, methods would probably be found of circumventing a specific duty on metal of Russian origin and already serious price competition has been experienced from Hungary, though Russia remains the biggest Communist supplier to the United Kingdom, having sent 7,477 tons in the first five months of this year. The total Russian exports of aluminium during 1956 amounted to 59,900 tons.

The problem is one which requires very careful consideration, because with the growth of Russian industrial capacity aluminium is by no means the only field in which Russia is in a position to adopt disruptive economic tactics.

Letters to the Editor

THE BURRELL MEMORIAL

SIR, I feel sure you will allow me to add an appeal to your report in ENGINEERING of 25 July (p. 100), of the installation and unveiling of the Burrell Memorial in Thetford on 12 July.

As you stated, the memorial has been provided by public subscription, but it is now the desire of the memorial committee to accumulate at least another £100, which will be invested and the income so derived devoted to the maintenance of the memorial, as found necessary. In fact, the present committee is now being formed into a legally-constituted trust to carry out this work. Also, I may say that a number of subscribers only contributed on the understanding that the monument was cared for in the future—a very necessary provision in view of curious schemes of compulsory purchase or street widening, etc., which crop up from time to time to-day. I am pleased to say this commitment is thus being honoured.

In conclusion, may I appeal to those individuals and firms who have not yet subscribed, and who might like to do so, to send their donations to me. They will be properly acknowledged.

Yours truly,
RONALD H. CLARK,
Secretary and Treasurer,
Burrell Memorial Committee.

Diamond Cottage,
Shotesham All Saints,
Norwich.
26 July, 1958.

STRAIN HARDENING OF CYLINDERS

SIR, In thanking Dr. B. Crossland for his comments published on page 68 of your issue of 18 July, on my contribution to the theory of the dilation of cylinders, I should like to assure him that I intended no disparagement of the work of Manning; I merely tried to travel a little further along the path which he had blazed. The strain hardening curve can, of course, be plotted either from experimental data or from the strain hardening constants if these are known, and Manning's arithmetical integration applied. The work involved might be little more tedious than my full integration, but could hardly compare with the convenience of the simplified approach which I suggested.

I must apologise if I inadvertently slighted Saint-Venant. In his book *Plasticity in Engineering*, van Iterson appears to claim equation 13 as his own, and I did not question his authority. I fully appreciate that this equation defines the conditions when the plasticising process has spread across the wall, but submit that these are, in fact, the conditions for initial yield of the cylinder as a whole. The Lamé type of equation cited by Dr. Crossland gives the pressure at which the inner fibres alone reach the yield stress and the cylinder is unlikely to dilate plastically in such circumstances.

In view of his criticism of equation 18, I would draw Dr. Crossland's attention to the statement in my article that "Throughout the paper . . . the word '*strain*' invariably means the true or logarithmic strain of Ludwik," (ENGRG., 13 June, '58, p. 756). Natural shear strain is the difference of two direct strains at right angles to each other. It must, therefore, itself be a logarithm; it is, in fact, the natural logarithm of a tangent or cotangent, the corresponding tangent or cotangent being the deformation ratio, not the strain. This definition satisfies the requirement imposed by constancy of volume that the sum of the three principal shear strains, like that of the three principal direct strains, shall be zero.

In torsion, the three principal directions are the radial direction and the pair of mutually perpendicular helices at 45° to the axis. As there is no strain in the radial direction, those in the helical directions must compensate each

Continuing Letters to the Editor

other. The stress system is that conventionally indicated in the adjoining Fig. 1. The outer square carries the direct stresses and the inner square the shear stresses with which they are associated.

Let us isolate the inner square, as at A B C D in Fig. 2, and consider the shears upon it. Shearing between A B and C D gives the parallelogram A′B′C D, and between C B and A D the parallelogram C′B″A D. These shears are equal to each other, and the angles A D A′ and C D C′ must each be half the measured angle of shear, ϕ. Let A C cut D B at P, and A′C′ cut D B at P′, then the triangle A′C′D is half the rhombus produced by shear. The principal direct strains are given by

$$\eta_1 = \ln \frac{D P'}{D P} \text{ and } \eta_3 = \ln \frac{A'P'}{A P} = \ln \frac{A'P'}{D P}$$

Therefore

$$\gamma_{13} = \eta_1 - \eta_3 = \ln \frac{D P'}{A'P'}$$

$$= \ln \cot \left(\frac{\pi}{4} - \frac{\phi}{2}\right)$$

$$= \ln \frac{1 + \tan \frac{\phi}{2}}{1 - \tan \frac{\phi}{2}}.$$

A more formal derivation could be given, but it is hoped that the foregoing will be sufficient for present purposes.

A few values of tan ϕ and γ_{13} are compared

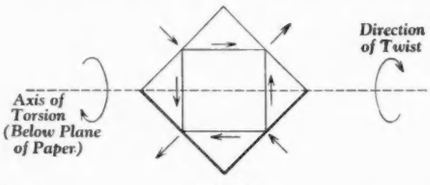


Fig. 1

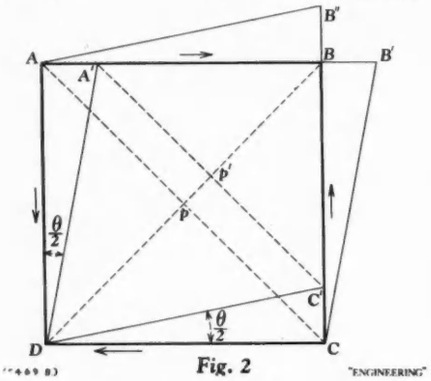


Fig. 2

in the accompanying table. It will be seen that the discrepancy between them does not become significant until the measured angle of shear approaches 20°, and the use of tan ϕ instead of γ_{13} would make little difference to the results given in my article.

ϕ	tan ϕ	γ_{13}
0	0	0
5	0·088	0·089
10	0·176	0·176
15	0·268	0·268
20	0·364	0·358
25	0·466	0·455
30	0·577	0·548
35	0·700	0·655
40	0·839	0·764
45	1·000	0·880

I agree with Dr. Crossland that the question of modulation does not arise if the strain-hardening curve of the material is determined under conditions comparable with those for which the information is required; in fact, I used this principle in dealing with his torsion experiments and in generating the strain hardening curve from the dilation experiments themselves. It is, however, clearly of much practical importance to know how to modulate from one mode of deformation to another; that is to say, to define with certainty the values of alpha and beta, and the remarks of Dr. Crossland merely emphasise the unsatisfactory state of present knowledge. It is encouraging to hear that the Mechanical Engineering Research Laboratory of East Kilbride, Glasgow, is interested in the subject, and it is greatly to be hoped that a definite pronouncement will be forthcoming in the not too distant future.

Yours faithfully,

E. Voce,
Senior Metallurgist.

Copper Development Association,
55 South Audley Street,
London, W.1.
22 July, 1958.

Talking to Americans

The series of articles which have appeared in recent issues of ENGINEERING under the heading *Talking to Americans—What They are Thinking and Where it Leads* has been widely appreciated, especially in the United States.

American observations on this commentary about themselves have included: "A factual view of our thinking on current problems without bias. You have brought to our attention a number of features which we are inclined to overlook." "Having known first hand some of the individuals and institutions which you visited, I must add that your article . . . certainly gives a true picture of what you encountered in this country." "I found that your ambitious undertaking had received refreshing and penetrating treatment." "Makes such delightful reading, and at the same time, conveys such a wealth of valuable and concise information."

The six articles are being reprinted as a special booklet (8*s*. each post free, 12 for 48*s*.), which can be ordered from The Publisher, ENGINEERING, 36 Bedford Street, London, W.C.2.

Plant and Equipment

U-TYPE BULLDOZER BLADE

An increase in handling capacity of 50 per cent has been claimed for the fitting of a U-blade attachment to a David Brown 50TD crawler tractor used by the National Coal Board, North Eastern Division Carbonisation Department, in stock-pile control at Smithy Wood Coking Plant, Chapeltown, near Sheffield.

Fitted with a standard straight angledozer blade the 50 h.p. tractor handled 90 to 100 tons over a 30 yard haul in each working hour. When a U-blade was substituted the machine handled 140 to 150 tons over the same haul and in the same period of time. Spillage over the relatively long distance was reduced considerably.

The design of the U-blade enables a bigger load of light material to be moved over a longer distance without excessive spillage at the ends of the blade than is possible with a conventional bulldozer or angledozer. Although, in this instance, the U-blade is being used to handle coal, it is equally suitable for use with almost any loose material. Further development is being carried out by David Brown Construction Equipment Limited, Hanworth Park, Feltham, Middlesex.

PYRAMID BENDING ROLLS

A heavy-duty pyramid-type plate-bending rolling machine has been constructed by the Bronx Engineering Company Limited, Lye, near Stourbridge. The machine has a capacity for mild-steel plate of up to 1,000 mm (3 ft 3¼ in) wide by 60 mm (2½ in) thick and has a rolling speed of 14 ft per minute. The main driving motor is rated at 40 h.p. and the adjustment motor at 20 h.p. The latter drives through worm gearing to adjust the top roll and there is a separate clutch on the shaft to permit the tilting of the top roll. An indicator shows the position of both ends of the roll at any time. Limit switches are fitted to prevent over-running either up or down. The rolls are mounted on a fabricated steel base enabling the housing and motor drives to be maintained in alignment. A magnetic brake is fitted to the main motor drive.

PLASTICS TUBE MONITOR

An instrument to measure and monitor electronically the wall thickness and concentricity of plastics tube, as it is extruded, is now available from Haynes and Haynes Limited, 32 Old Church Street, London, S.W.3. It is made by West Instrument Limited.

The instrument consists of a detector head, through which the tube to be monitored passes, and a control cabinet, which receives the information and shows on a meter the thickness of the tube being monitored. This meter has adjustable high/low controls which can be pre-set to upper and lower tolerance limits. Any departure outside those limits actuates an alarm. The detector head is normally mounted between the cooling bath of the extrusion press and the haul-off unit. Since no access to the inside of the tube is required, the head can be easily attached to the tube at any time after extrusion has commenced. The concentricity of the tube bore is checked by scanning the circumference of the tube with the head. A production record may be charted on the paper reel of an ordinary recorder.

Continuing **Plant and Equipment**

GREASE FROM EDIBLE OILS

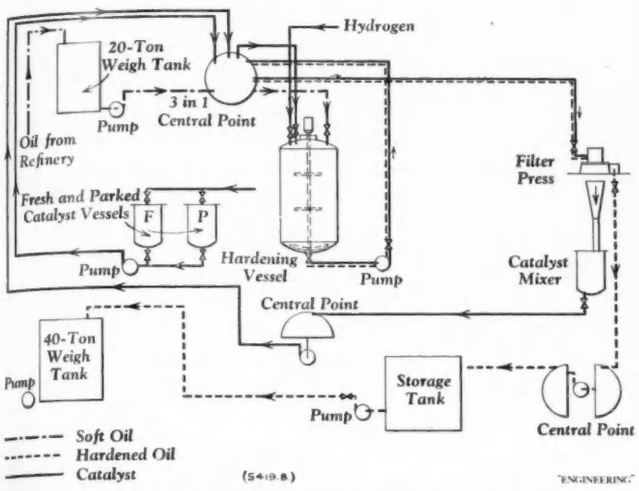


Fig. 1 Flow diagram for the hydrogenation cycle. Elaborate precautions are needed to meet the fire risk.

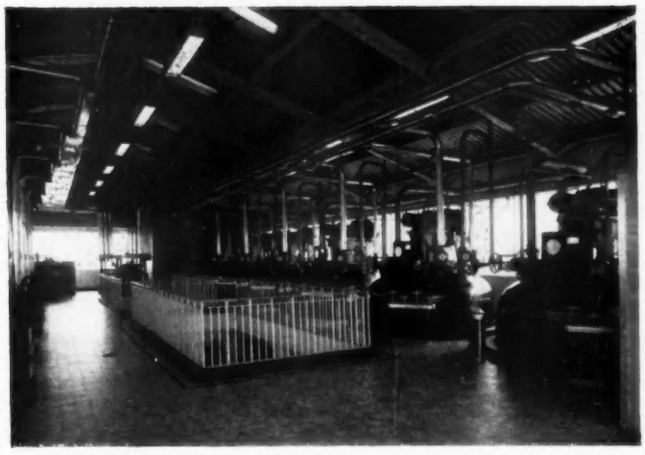


Fig. 2 The upper storey is the operating floor for the hydrogenation vessels (right) and the filter presses. At the far end is the central pumping point.

TO RENDER the factory self-contained, and avoid the transport of hardened oils from other sources, it was decided to install a hydrogenation plant at the Stork margarine works of Van Den Berghs and Jurgens Limited at Purfleet, Essex. The plant has been designed for an output of 60,000 tons of hardened oils a year. A new boiler house and turbine house have also been built, and the whole electrical system has been modernised.

The process of hardening oils implies the addition of hydrogen to a light oil to increase the molecular size and so, eventually, to convert it to a grease. Consequently, the new plant includes a section for the production of hydrogen. The raw material used for this purpose is propane and the process takes place in a Power-Gas Hercules plant. The propane is supplied by road tankers and stored in pressure vessels from which it is fed to a reforming furnace. In normal conditions, there is enough heat in the atmosphere to vapourise the propane but provision is made for the action to be assisted by hot condensate.

In the reformer the propane is mixed with steam and heated to 1,600° F while passing over a catalyst. The gas produced thereby contains about 20 per cent carbon monoxide, which is converted to the dioxide and removed by absorption in mono-ethanolamine, in two stages. The last traces of the monoxide are converted to methane by a nickel catalyst. The hydrogen, which is produced at the rate of 24,000 cu. ft per hour, is then dried and stored at 90 lb per sq. in in Horton spheres, being of a purity of not less than 99·5 per cent.

The whale and other oils are brought by sea (this is the first time that whale oil has come into the Thames) and pumped in to store, the tankage for which has been enlarged to hold 30,000 tons. This large stock is necessary owing to the seasonal character of the production of whale oil. After refining, the oils are pumped to weightanks in the hydrogenation plant and, thence, through a central pumping point, to any one of the six 18 ton hydrogenation vessels. The upper storey of the building, which is the operating floor for the hydrogenation vessels and filter presses, is illustrated in Fig. 2, attached, where the central pumping point will be seen at the far end of the view. A flow diagram of the hardening process as a whole is given in Fig. 1.

The treated charge is pumped to one of the eight filter presses where the catalyst and sludge are removed. The hardening oil passes to storage tanks and most of the catalyst is recovered and recirculated, enough fresh material being added to make up the correct charge.

Since there are large amounts of hydrogen involved in the process, special precautions have been taken to avoid the danger of fire. All pipe work, structural steelwork and the casing of the electrical system is bonded to earth, and a lightning protection scheme covers all buildings and outdoor plant. In addition, the electrical system is subjected to internal pressure and is continuously purged by dry air. This precaution is extended to all motors. At the end of each distribution line there is a bubble-glass through which the purging air escapes and by which an indication is given that the system is functioning adequately. There are also relays that will isolate the system in the event of pressure failure. Since these relays must remain energised at all times they are designed to be intrinsically safe.

The new boiler house has been built and two pass-out turbines installed to provide the steam required for the process work and some of the power used in the plant. The consulting engineers for this work were Merz and McLellan. A feature of the boiler house is that the firing aisle is the only part enclosed. The installation comprise five Babcock and Wilcox oil-fired boilers with their associated pumps and Permuttit water treatment plant. These boilers supply two Brush turbo-alternator sets at 400 lb per sq. in, one set being rated for 500 kW and the other for 3,250 kW. Each set has two turbines in line driving an alternator through a David Brown 8 : 1 reduction gear. The alternators normally run in parallel with the Grid supply. From these sets, steam is supplied through Electroflo controls to the process departments in two mains; one, of 7 in diameter, working at 170 lb per sq. in, and the other, of 18 in diameter, working at 38 lb per sq. in.

For the buildings the main contactors were G. Percy Trentham Limited while the Purfleet staff and the technical division of Unilever Limited were responsible for the process plants.

PREVENTING VIBRATING SCREENS FROM CLOGGING

When dry screening material on sieves having apertures of about $\frac{1}{8}$ in or less, it is often difficult to prevent the screen cloths from "blinding" when the material has a high moisture content. Such a problem arose in a quarry installation where four standard 4 ft by 10 ft mechanically-vibrated Gyrex screens, supplied by the Erith Engineering Works of the General Electric Company, Limited, are used for sizing crushed rock of $\frac{3}{8}$ in mesh, with about 30 per cent below $\frac{1}{16}$ in. The screen decks are fitted with $\frac{7}{32}$ in and $\frac{3}{32}$ in square-mesh high-tensile steel wire cloths. In rainy weather the stone fines contain about 10 to 12 per cent of water, although the overall moisture content of the rock may not be more than 5 per cent, and the damp material used to clog the lower $\frac{3}{32}$ in screen completely in about half an hour. Screening had then to be suspended while the screen was cleaned manually with a wire brush. Even in dry weather the position was not much better, as water sprays are used in parts of the plant for dust control, and the stone fines were still too damp to be treated satisfactorily on the screens.

It was therefore decided to fit electric heating equipment to the lower screen cloths, and this was done by the G.E.C. in collaboration with the Woden Transformer Company Limited, Bilston, Staffordshire. Low-voltage current is passed through the wires of the screen, which is kept at a temperature of 40° C for most of the year, but can be dropped to 30° C in very hot weather. The throughput is about 25 tons an hour, and the $\frac{3}{32}$ in screen is now virtually clear at all times, whatever the condition of the fines may be. With power at 1μ per unit the cost of heating is about 0·75μ per ton of screen feed.

A similar problem occurred at the Blaengarw coal-preparation plant, South Wales, where four G.E.C. Sherwen electromagnetic screens were installed for sizing $-\frac{3}{8}$ in coal on $\frac{1}{16}$ in. A moisture content of 4 to 7 per cent in the coal rising to 8 to 12 per cent in the fines, made effective screening virtually impossible, but electric heating has overcome the difficulty.

For the application of electric heating the screen cloths, divided into two longitudinal sections, are insulated from the deck and from each other by long strips of non-conducting material, and the ends are clamped between bars of tinned steel, to which terminals are attached. Current is taken from one of the busbars on the low-tension side of a transformer to terminals on the top of one of the longitudinal sections, by means of rubber-covered cables. The current passes through the wires of the screen to its lower edge, from which it is led by cables or copper strips to the bottom of the second section. Thence it passes up the wires to the upper edge, and so by cables back to the transformer. Small variations of this arrangement are necessary to suit different designs of screen. Flow switches can be fitted to cut off the current immediately the feed fails.

Continuing **Plant and Equipment**

HEAVY VEHICLE DIESEL ENGINE

Detachable Caps to Combustion Chambers

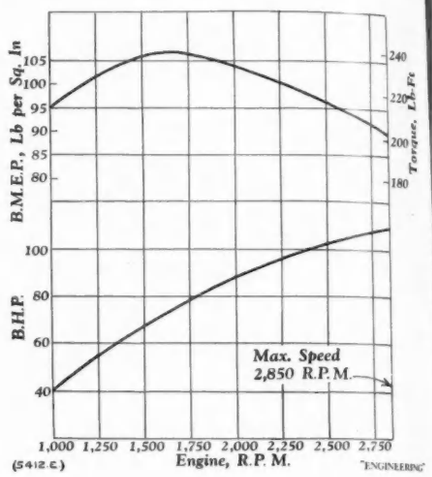
AN addition to the range of engines made by F. Perkins Limited, Peterborough, is the F340 110 h.p. diesel, which is to be offered in the new American-built Ford 154 in wheelbase F600 trucks. These trucks have a gross vehicle weight rating of up to 19,500 lb and are made with a wide range of custom-built bodies.

The six-cylinder F340 is rated at 110 h.p. at 2,850 r.p.m. and develops its maximum torque of 240 lb-ft at 1,700 r.p.m. Bore and stroke are 4 in and 4·5 in respectively, giving a displacement of 339·3 cu. in; the compression ratio is 17·5 to 1. Weight dry is 914 lb approximately, without flywheel, housing or starting motor.

The cylinder block and crankcase are integrally cast in high-duty iron and are fitted with pressed-in dry liners. The head is also of cast iron and the valve rocker gear is enclosed in a die-cast aluminium cover; spherical combustion chambers are used, formed half in the head casting and half in detachable steel caps. The camshaft is cast iron with chilled cams shaped to give parabolic acceleration; the front bearing is pressure-lubricated and the remainder, as well as the cams, by a series of weirs which form oil baths. Push rods and rockers with screw adjustment operate the valves.

The crankshaft is forged molybdenum steel and runs in seven main bearings. Both pin and main journals are induction hardened. A vibration damper is fitted to the cast iron crankshaft pulley. The camshaft and the fuel pump are driven from the front end of the crankshaft through a triple roller chain. The pump is of the in-line type and is fitted with a pneumatic governor to control the engine speed. Also incorporated is an altitude control which utilises the variation in barometric pressure when operating at high altitudes to reduce the maximum amount of fuel which can be delivered by the pump. An automatic device is also incorporated in the pump coupling to advance or retard the point of injection according to the changes in engine speed. The injectors have two sprays, one directed into the combustion chamber and the other into the cylinder itself.

The F340 diesel engine develops 110 b.h.p. at 2,850 r.p.m. for a dry weight of 914 lb.



Performance curves for the F340.

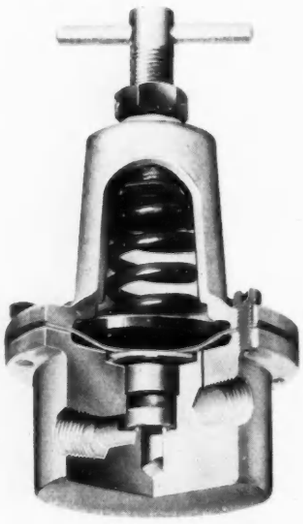
Cooling is supplied by a centrifugal water pump driven from the front end of the crankshaft and feeding to a cast gallery on the cylinder block. A thermostat in the cylinder head controls the by-pass for rapid warm-up. A gear-type oil pump delivers the lubricating oil through a filter to the main gallery in the crankcase which has tappings to the main bearings and the camshaft. The cylinder bores and gudgeon pins are splash lubricated.

To aid starting under cold conditions a single-pole 12 volt heater plug and a starting fluid injector are fitted in the induction manifold. A starting fluid priming pump is also supplied, to be fitted in a convenient position and connected to the starting fluid atomiser.

LOCKING PNEUMATIC CONTROL VALVES

For the many cases when it would be safer, and the possibility of a plant shut-down would be avoided, if the control valve could be arranged to remain in its last position should there be a failure of the instrument air supply, there has been developed the Mason Neilan type 76 lock-up valve manufactured by Crosby Valve and Engineering Company Limited, Ealing Road, Wembley, Middlesex. This brass valve, shown in the illustration, is connected in the air line between the control instrument and the diaphragm connection of the control valve, and its signal connection is connected to the instrument air supply. When the air supply is normal the signal pressure underneath the diaphragm compresses the spring to hold the valve in the the open position, thus enabling the instrument output to pass straight through to the control valve diaphragm in the normal way.

To lock pneumatic control valves in their last position should the air supply fail, this Mason Neilan valve has been developed.



Immediately the instrument air supply pressure drops below a predetermined value, the spring moves the soft-seated plug downwards shutting the valve completely, and locking the last instrument output pressure signal in the control valve diaphragm case. Provided the air line connections at the control valve diaphragm and the lock-up valve are tight, the control valve will be locked in this last position for an indefinite period allowing the air failure fault to be located and rectified. As soon as the air supply is restored the lock-up valve will reopen and normal process control will be re-established without any major upset.

The rating of the lock-up valve spring has a range from 10 to 40 lb per sq. in.

TRANSISTORISED COUNTER

The P12C electronic counting unit made by the Electronic Machine Company Limited, Mayday Road, Thornton Heath, Surrey, has now been equipped with a small transistor amplifier driven by a selenium barrier photocell. The amplifier output operates a relay which can be used to work an electromagnetic counter or perform some control function. The use of the transistor eliminates any warming-up period and also any fear of overheating, while the selenium cell reduces focusing troubles.

POCKET EXTINGUISHER

An aerosol fire extinguisher is the latest product of Deb Chemical Proprietaries Limited, Forfar Chemical Works, Belper, Derbyshire. The standard can of "Gwish" contains 12 fluid ounces of extinguisher. Depressing the cap releases a spray which carries for 6 ft with a 3 ft diameter coverage. It is stated that flames are doused instantly. As the fluid is a non-conductor, Gwish can be used safely on electrical fires.

The great advantages are the convenience, portability and low cost of the cans which can be at hand for instant use.

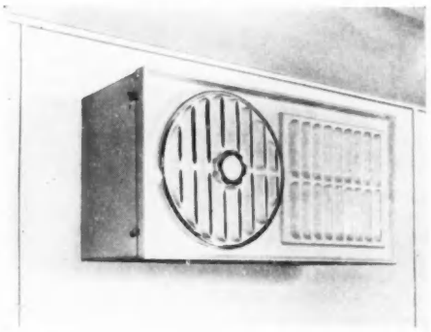
SELF-CONTAINED AIR CONDITIONING UNITS

A new range of self-contained air conditioning units—claimed to be the most compact ever produced for marine use—is being introduced by Thermotank Limited, Helen Street, Glasgow. The range, known as Series P, comprises two water-cooled units and two air-cooled units, all of which have been proved under tropical working conditions. They have been designed for low-cost, full air conditioning of selected spaces, and the capacity of a single unit is claimed to be adequate to deal with the average ship's cabin.

The approximate overall dimensions of the water-cooled versions are 28 in long, 14 in high and 11½ in deep—the air-cooled units having the same facia size but being 7 in deeper. The casing is acoustically, as well as thermally, insulated to ensure quiet operation, and is fitted with attachment bars to facilitate surface mounting on a wall or bulkhead.

Each unit incorporates an hermetically-sealed motor/compressor operating on Freon 22 refrigerant; cooling coil; washable nylon mesh air filter; thermostat; and a rotatable 10 in diameter air discharge grille for draughtless diffusion of the air after it has been filtered, cooled and dehumidified. The units are designed to operate on an a.c. power supply.

The water-cooled units are designed to operate with seawater temperatures up to 90° F, and the air-cooled versions with a maximum ambient temperature of 120° F. The former have loadings of 4,480 and 7,200 B.t.u. per hour, and the latter 4,400 and 6,700 B.t.u. per hour.



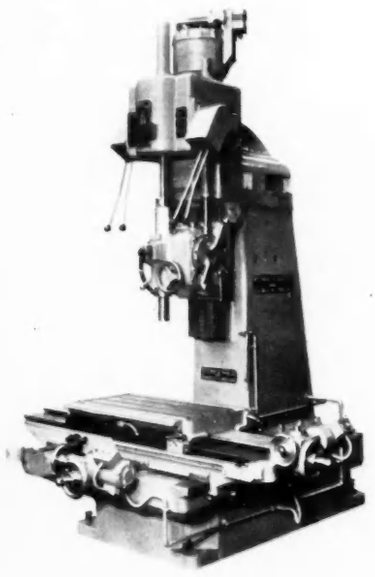
For air-conditioning a cabin, this unit measures 28 in by 14 in by 11½ in deep.

PRECISION DRILL BORER

The precision-type drill-boring machine shown in the accompanying illustration and made by Kitchen and Wade Limited, Arundel Street, Halifax, has a 1¾ in multi-spline spindle to take No. 4 Morse taper as standard, with the alternative of No. 5 taper if desired. The length of feed is 11 in. It is a workshop machine for drilling, boring, tapping, facing or chamfering at fast cutting times.

The spindle head has 12 in of adjustment on the front face of the column and is balanced by a dead weight. The gearbox is driven by a constant-speed 5 h.p. motor and offers a choice of 12 spindle speeds from 45 to 1,500 r.p.m. as standard; other ranges can be supplied if required. There are nine power feeds from 0·002 in per rev. to 0·02 in per rev., obtained by the hand levers. A reverse lever allows the full range to be obtained in both up or down directions.

The table has a working area of 3 ft by 1 ft 8 in and has 15 in in and out travel and 2 ft 6 in cross traverse. Both motions are motor-driven. There are two index dials for each movement, one reading to tenths and the other to thousandths of an inch; where greater accuracy is needed measuring rods can be fitted into tracks, and used with dial gauges.



Motor-driven table movements are a feature of this precision drill-boring machine.

STAND-BY GENERATORS

The stand-by plant for the new radio telephone link now being constructed in Jamaica, is to be supplied by Austinlite Limited, 28 St. James's Square, London, S.W.1. It consists of two units, one of 2·5 kVA to be installed at Kempshott, and one of 7·5 kVA for Christiana; both are of basically the same type of construction.

At Kempshott a Ruston and Hornsby 2YB water-cooled diesel engine is coupled through a magnetic clutch to a heavy steel flywheel mounted in separate bearings. This in turn is coupled to an alternator and to a slip-ring electric motor. All these units are mounted on a common bedplate. In operation the essential load is always supplied by the alternator and has no connection to the mains supply; no changeover contactors are therefore needed. Under normal conditions, the motor is driven by the mains and drives the alternator, but on a mains failure the motor is disconnected and the magnetic clutch engaged. The inertia of the flywheel is sufficient not only to start the diesel engine, but also to maintain the voltage during the changeover within ± 2½ per cent and the frequency within 10 per cent. Upon mains restoration the clutch is cut out, the diesel engine stopped and the motor resumes the drive.

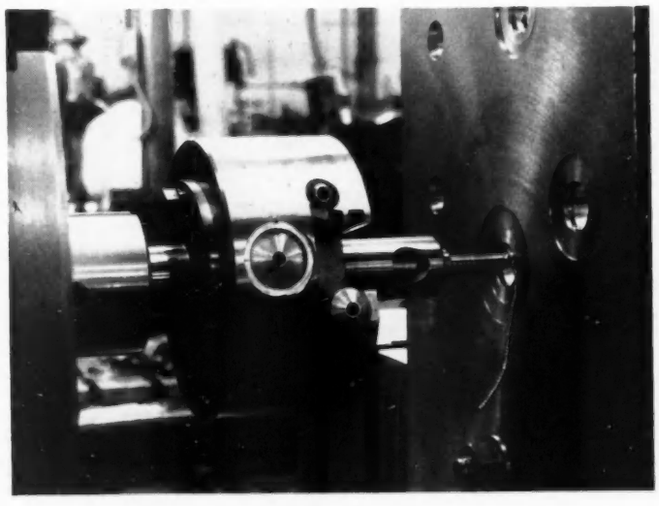
The plant at Christiana is essentially the same, but the engine is a Lister FR3; both the alternators and both the motors were made by the Electric Construction Company Limited.

AUTOMATIC BORING HEAD

A cutting head that will bore, face, or undercut on repetition work has been produced by the Swindon Tool Company Limited, Trading Estate, Cheyne Manor, Swindon. It is shown in the illustration. The chief feature of the tool is that the cutter moves outwards during the cut under an internal hydraulic pressure until it reaches an adjustable stop preset to the required dimension. At the end of each operation, the cutter is merely returned to its original position by hand and will then repeat the cut on the next workpiece. The tool can also be used as a normal boring head in which case the automatic movement is locked out of action.

To take for example a facing operation as shown in the illustration. The cutter is entered in the initial hole with the control valve closed and the sliding head in the central position. The lock is disengaged and the control valve opened. When the tool bit touches the side of the hole the micrometer stop is adjusted to give the facing diameter. The cut is then commenced and the sliding head moves the tool outwards as the material is removed until it contacts the micrometer stop. The depth of facing is taken care of by the normal machine controls. To return the head to the centre, the return nut is rotated by a spanner, which frees the hydraulic pressure (by opening a by-pass) and allows the head to be returned by hand.

The micrometer stop adjustment is calibrated in 0·002 in divisions, one complete revolution being 0·100 in. The micrometer screw, which is used to set the tool when operated as a normal boring head, is calibrated in 0·001 in divisions. When the latter is in use any backlash is taken up by the hydraulic pressure. During facing operations the micrometer screw is disengaged to allow the sliding to move under the action of the hydraulic pressure; the rate of movement can be regulated by the feed control valve already mentioned. Unlike boring heads with mechanical feeds this tool is entirely self contained and can be fitted in any standard drill.



The sliding head of the boring tool will feed outwards under hydraulic pressure until it contacts an adjustable stop.

Companies in the News

Process Plant Makers

Several companies producing plant and supplying equipment to the coal, gas, steel, chemical, petroleum and nuclear industries have published their annual reports recently. Most of them are large users of steel plate and special steels, so that their activities have been restricted since the war by shortages of supplies. Whessoe Limited, whose profits increased from £942,000 to over the £1 million mark, look ahead to further considerable expansion, believing that markets for their products will " expand in line with the predicted growth in demand for energy, based notably on petroleum fuels and nuclear power." Their chairman, Mr. C. M. Spielman, told shareholders that Whessoe were planning to have more shops erected on land they are acquiring adjoining their works at Darlington. These shops will be ready in the early 1960's but, until then, Mr. Spielman considered it unlikely that the expansion in demand for petroleum and nuclear power plant would be supported by steel plate availability.

Whessoe's short-term prospects have been considerably affected by the crisis of last September and the restrictive financial measures taken by the Chancellor to overcome it. Their year (ended March 31) opened with a very full order book and new orders received for the first six months more than matched their production. Thereafter, a sharp change took place. The slowing down of capital plant programmes led to some orders being cancelled, and to postponements. The net result, said Mr. Spielman, is that " although all departments will be kept fully occupied during the first half of our current financial year on orders already received, there may be some slowing down thereafter."

W. P. Butterfield Limited were affected in the same manner, but more so since they rely for a substantial part of their turnover on galvanised steel products for householders. Mr. C. Butterfield, their chairman, expresses the hope that the reduced Bank Rate will lead to a resumption of capital expenditure by the petroleum industry as quickly as the raising of it led to a halt. Such is the hope of all process plant makers, for their main customers are the basic heavy industries—coal, iron and steel, petroleum chemicals, nuclear power—all of which require favourable borrowing conditions before they can contemplate launching further rounds of expansion. This problem—of credit restriction and cyclical movements in demand—is discussed briefly in the following note.

Temporary Reduced Investment

The two large groups making plant for the fuel and steel industries, Head Wrightson and Woodall Duckham, have published their annual reports recently, in which their chairmen gave a detailed and interesting review of their companies' outlook on the future. Woodall Duckham, like Head Wrightson, have been built up largely on the construction of plant and supply of equipment for the steel, coal and gas industries. Head Wrightson's activities include in addition plant for the non-ferrous industries, rolling stock, dock gates, petroleum refinery equipment and nuclear engineering. They declared a record trading profit of £1·76 million, nearly £300,000 more than in 1956. " For more than a quarter of a century," said their chairman, and managing director, Mr. Richard Miles, " our trading profit has shown an upward trend," a glowing testimony to the wisdom of being specialists in heavy engineering. Woodall Duckham's profits before tax were up by nearly £200,000, to £1·26 million on a turnover of some £15 million.

The short-term prospects of both companies continue to be very satisfactory. At the end of 1957 Woodall Duckham had over £22 million of unexecuted work but their chairman, Mr. T. C. Finlayson, emphasised that " any steps which contribute to make it more difficult for industry to spend capital " must have their effect on the Group's affairs. Already the dear money and credit restriction policies of the Government have been reflected in the volume of orders received during the last year, but he told shareholders, " Your directors consider that this is a temporary phase which will correct itself as the national economy expands once more."

Mr. Richard Miles is more inclined to caution in his assessment of the situation, though his review suggests considerable confidence in his company's ability to compete effectively. " Our recent exceptionally heavy capital expenditure," he said, " is having its effect in broadening the basis of our productive capacity, and in increasing efficiency. The fact that we provide equipment, based on continually improving techniques and coupled with vigorous selling and technical service, should also have its effect." Nonetheless he warned that it would require " more boldness than the present situation warrants to forecast results over the next few years." Mr. Miles believes that the future of the country and our living standards can only be assured, in the absence of material resources, by " selling brains "—hence his company's considerable expenditure and efforts in research. An interesting qualification, however, which many business men would endorse is that " pioneers are not always the people to whom accrue the most profitable returns." This was said in the context of Head Wrightson's activities in nuclear engineering—at present, it seems, more glamourous than profitable.

Demag in Lower Gear

German metal and heavy engineering industries are beginning to experience a downturn in trading, and growing competition at home and abroad. There is abundant evidence to suggest that they have reached a critical phase in their post-war development where keen prices, quick deliveries and first-class salesmanship will be essential to avoid falling back from the very high level of output reached in the past few years. The annual report of Demag Aktiengesellschaft, Duisburg, contains a most interesting and detailed statement on the German economy and on heavy industry's prospects. On the evidence available to them, they said that generally speaking " it has long been undeniable that the expansion in demand in our branch of mechanical engineering, which enabled prices and labour costs to rise continuously without appreciable market resistance, has now come to an end."

The main factor in the slackening in investment activity during 1957 is, for German as well as British engineering companies, the need of underdeveloped countries to cut back orders " so as to keep them in line with the reduced earnings of their raw materials in export markets as a result of falling world prices." Economic growth in Western Germany continued during the year and industrial output increased by 5 per cent; capital goods production rose by only 4 per cent, compared with 9 per cent in 1956, and 23 per cent in 1955. The industry's turnover was mainly sustained by exports which rose by 25 per cent, whereas home sales increased by only 3·3 per cent. The order intake fell just short of the 1956 figure and the trend is definitely downwards. Demag are well covered by orders for large industrial plants which are spread over several years, and a high degree of diversification enables them to absorb setbacks in particular industries. Nonetheless, future prospects and the level of employment " are largely dependent on the investment possibilities which exist in the iron and steel, mining and building industries " and these are not good almost anywhere in the world.

The future is depending more and more on increased exports. Demag can maintain full employment only by expanding their export business and thus " deliberately accepting an increased element of risk." This is very much the position of our own large engineering groups for whom, as for Demag, technical advance and the entry into new fields (such as atomic reactor construction) offer the best prospects.

Peak Manufacturing Profits

The profits of industrial companies reporting during the first half of this year continue the upward trend of the past five years. Manufacturing industry in particular has done well—better than the distributive trades and non-manufacturing industry generally, which last year was the most prosperous sector. Within manufacturing industry, the engineering and metal manufacturing sections showed a better than average performance, with the exception of shipbuilding. Some industries, such as clothing, cotton, wool and rayon showed a reduction in trading profits, though not as large as might have been inferred from those industries' own statements.

The bulk of the profits (1,858 reports) included in the *Financial Times*' analysis were earned during 1957. Later arrivals, more influenced by the experience of the first few months of 1958, indicate a slackening in the rate of increase and, in some cases, an actual decrease. Our review of company reports has shown quite clearly that profits on 1958 trading by the engineering and metal industries will be substantially lower than last year, mainly because margins have decreased. This is a continuing trend, despite the marked falls in raw material prices. Increasingly companies are being forced into price reductions by the growth of competition both at home and overseas. Order books are generally lower and only the outstanding companies in the " growth " industries are booking more orders than they are able to deliver. The whole statistical picture suggests a reduction of earning power and a slackening of activity.

Seventy-five Years of Growth

The seventy-fifth anniversary of Holden and Brooke Limited this year was marked by the publication of a brochure which tells the story of the company since it was founded in 1883 by two young engineers, whose sons now head the business. The two founders, Robert G. Brooke and Harry Holden, were both employed by Sharpe Stewart and Company Limited, who were at that time important locomotive builders in Manchester. In the words of the present chairman, Mr. H. L. Holden, they had " few resources, little money; but had determination and inventiveness." They set up business as makers of the boiler feed injector invented by Giffard.

In their early days they also made small gas engines, door locks and automatic sweet delivery machines, but soon concentrated their efforts on the production of boiler components and added steam traps, steam dryers, oil separators, feed-water heaters and a range of heat exchange equipment. At the beginning of the century they entered the centrifugal pump market and developed accelerators for low-pressure hot-water systems. In 1926 they introduced the " Selfix," which was the first pump specifically designed for hot-water circulation and is to-day one of the company's main products.

The story told in the brochure is a chronological account of the company's progress, and includes the acquisition of Frank Pearn and Company Limited, completed in 1950. Pearn had a similar history of enterprise and engineering good sense. Founded by Frank Pearn (at the age of 21) after the completion of his apprenticeship to a firm of pump makers, they developed a full range of ram pumps and vacuum pumps. The two businesses were integrated in the early 1950's and now operate under the name of Holden and Brooke.

Special Articles

MOVING OUT OF LONDON

Many small engineering firms are bursting their seams in overcrowded London boroughs or trying to do increasingly accurate precision work in dark and unsuitable premises. They should be interested in the campaign which the London County Council have started to persuade industrial firms to leave London and establish themselves in one of the small towns which are expanding under the terms of the 1952 Town Development Act.

This Act was intended both to help overcrowded areas such as London and the other great industrial cities to deal with their housing problems and to give small towns, with dying industries or needing diversification of employment, opportunities to attract employers. The "exporting authorities," as they are called, are linked with reception towns and provide financial assistance, in addition to the housing subsidies of £29 a house provided by the Exchequer. They are empowered to pay a further subsidy of £8 a year for 10 years on each house provided for a tenant from their areas, who may be either an applicant on their housing lists or one of their existing tenants.

In order to discover applicants who have the qualifications required by employers and are willing to move out, the exporting authorities collaborate with the Ministry of Labour in the preparation of an Industrial Selection Register. Preference is given to those on the register when firms in the developing town notify vacancies to the Ministry of Labour. There are at present 55,000 persons on the register of the L.C.C. In some cases the operation of this register and the financial partnership between the exporting and receiving authority in providing houses is all that is needed. The L.C.C., for instance, has arrangements with both the Borough of Luton and Luton Rural District for housing development by which they expect to help in the building of 2,400 dwellings. In these cases there is, at present, ample local employment. A similar situation exists at Aylesbury and at Bury St. Edmunds.

In some cases the reception towns have commenced industrial development on their own. For instance, Bletchley started developing its own industrial estate after the war; four firms from the County of London and six from Greater London have established themselves in it. Over two hundred families have moved from the County of London and the plan is to build 1,400 dwellings over the next few years if sufficient employment can be provided. At Swindon an expansion of 6,000 dwellings is planned, of which over 1,200 have so far been built. Six firms have left the London area since 1953.

In spite of these plans the operation of the Act has been proceeding very slowly. As far as London is concerned it has only been responsible for the removal of 5,000 people out of a total of about 300,000, most of whom have been housed in the New Towns or in the L.C.C.'s own out-county estates. The L.C.C. is anxious, therefore, to operate the other powers given it under the Act, by which it it can assist the councils of reception towns to attract both industry and workers together. The council will finance the building of factories for lease or sale on mortgage to industrial firms at present situated within its area. When a factory has been built it is purchased by the council of the receiving area, who become the landlords. In some cases the L.C.C. is going further and assisting the receiving authority in acquiring land and laying out an industrial estate. Such arrangements for what is known as an "agency" scheme have been made at Haverhill, Thetford, Huntingdon and Letchworth.

As in the New Towns, the majority of firms moving to Developing Towns are small and in light industries. Precision engineering plays a prominent part, but there is little heavy industry. Most of these firms have been expanding fairly fast since the war, and the chief motive for moving has been to acquire more space, and better working conditions. Small firms do not seem to experience difficulty in persuading most of their employees to move with them; although there is, perhaps naturally, more difficulty with senior staff who may have their own houses in London. Families seem to have less difficulty in settling down than in the New Towns; no doubt because the Developing Towns are already settled communities, however different from a London borough. In Bletchley and Letchworth there have, in the past, been difficulties caused by the voracious labour requirements of Vauxhall Motors at Luton; but this seems to have been a passing phase and, in part no doubt because of the earlier instability of the motor-car industry, workers now seem to prefer the relative security of the smaller firms.

The chief difficulty which engineering firms have experienced is in attracting more highly skilled workers and technicians, especially draughtsmen. The Treasury will not approve, except in special cases, the Exchequer housing subsidy for workers coming from outside the area of the L.C.C. or other exporting authority. It is difficult to recruit draughtsmen in London, partly because the need for a house is more likely to be found among young people, and the young draughtsman is looking for a variety of experience in different firms which is not available in the Developing Towns. On the other hand, there are plenty of draughtsmen in the North who have been working in heavy industry and who are anxious to come south and widen their experience. It is hoped that the Treasury will allow a certain number of these to be recruited as key workers so that the subsidy can be paid; although at least one firm is proposing, if necessary, to pay the subsidy itself for an initial period, after which it hopes that its employees will have settled down and built their own houses.

The problem of technical education naturally looms large in firms engaged in advanced design and precision work. In some of these towns provision is at present inadequate. In most cases, however, there are technical colleges within travelling distance, even if the transport facilities are not always convenient; and employers are generally willing to provide generous release of their employees for part-time study. Under these circumstances it has been found that the best apprentices will readily overcome the travelling difficulties.

Apart from the fact that Greater London is already far too large and overcrowded, the economies of manufacturing in London are hardly likely to improve as traffic congestion becomes worse. On the other hand, expanded road development and railway modernisation programmes and cheaper telephone charges will make less important the location of manufacture alongside suppliers and customers. At the same time the spaciousness, cleanliness and healthy living conditions that can be provided in smaller towns should encourage greater accuracy and efficiency. That, so far, has been the experience of firms who have taken the plunge.

PLANNING TO USE POTENTIAL SKILL

The conference on apprenticeship called by the Royal Society of Arts uncovered no new problems, but underlined the commonest failings of technical education and training: insufficient numbers and inadequate standards. The conference was opened by Mr. Robert Carr, M.P., who said that as he was no longer a member of the Government he was able to speak more freely. This freedom allowed him to make some pretty severe criticisms, which were supported by later speakers, of the apathy of employers' associations either in making estimates of future requirements of skilled labour or in providing the organisation needed if small firms were to be able to make their contribution for apprentice training.

In a conference of the converted, mostly from large firms or from schools and technical colleges, it is not surprising that much was said about the lack of knowledge possessed by small employers and by parents of the facilities available in the technical colleges or provided by the new group apprenticeship schemes now operating in different parts of the country. There were frequent suggestions, and not only from trade-union speakers, that small firms still looked upon their young employees as cheap labour and were apprehensive of the cost of schemes which might involve at least one-day release for attendance at college.

Related to this problem of getting small firms to play their part in training, especially of the large numbers of young people who will be becoming available as the population "bulge" leaves the schools and National Service ends, is that of the relationship between industry and the colleges. Undoubtedly the teachers in many colleges are not up to date; perhaps because they are so overworked that they have little time to visit industry. But industry itself is not playing the part it should, either in providing some of its top men to sit on the boards of governors or by inviting the staffs of the colleges into its works to see what is going on or to assist in specific jobs.

The conference heard interesting papers on group apprenticeship schemes which could provide the answer for the small firm; on pre-apprenticeship courses; on joint training centres for particular industries (for example, the foundry trades) and on block release schemes by which the apprentice attended the college full-time for a number of weeks instead of the usual one day a week. Such a scheme operates for the heating and ventilating industry.

The discussion covered many other subjects; including the school leaving age, the curricula of secondary schools, "liberal" education for apprentices, the wastage of students and appropriateness of courses and greater incentives for those who serve indentured apprenticeships, but, in the end, the question that remained unanswered, although raised by several speakers was whether industry was likely to do by itsel, what was required or whether the Government would have to play a bigger part than hitherto in this country.

In this connection a valuable short contribution was made by Mr. H. A. Warren, principal of South East London Technical College, about the methods used in France, Germany and Holland. Although the period of apprenticeship is shorter and there is less opportunity for a craftsman to rise up the technical ladder, more attention is paid on the Continent to the educational side. In France the whole period of training is spent in a *Centre d'Apprentisage* where training takes place in a production atmosphere. In Germany also more use is made of full-time education for craft apprentices. The greater interest by parents and boys in education and training does not seem to be due to greater pay differentials so much as to the higher prestige accorded to the skilled craftsman.

In contrast to the difficulty being experienced in setting up the National Apprenticeship Council recommended in the Carr Report, there already exist in these countries central organisations, either set up by government or industry, which not only organise courses and control standards but collect statistics and make estimates of forward need. In France these bodies are supported by a special tax on employers using skilled labour.

Special Article

AN OLD-FASHIONED WINDMILL GENERATES ELECTRICITY

By Rex Wailes

In recent years, efforts have been made in the Netherlands to determine an economical method of using the surplus wind power from the old-fashioned type of windmill to generate electricity. The most advanced project so far, de Kraai (the Crow) mill at Westbroek, near Utrecht, was officially opened on July 12.

De Kraai windmill has been equipped for electrical generation with shuttered sails and the mill is provided with a servo motor, controlled by a wind vane, for turning the cap.

Taking a brief look at the history of wind power, the first natural source of power harnessed by man was the wind which drove his sailing boats; but it was not until about 600 years after the first known reference to a water mill, in A.D. 83, that we find a somewhat vague reference to windmills in Persia. They are still there, in Siestan, but are very unlike those with which most of us are familiar, for their sails are mounted on a vertical shaft and turn in a horizontal plane. The first water mills were constructed in the same fashion, with the wheel on a vertical shaft which drove a millstone above it direct, without the use of intermediate gearing. This type of water wheel still persists in Scandinavia, the Balkans and the Near and Middle East.

The Romans introduced the watermill as we know it in the West, with a wheel on a horizontal shaft and a right-angle drive to the millstone above through gearing. The western type of windmill is simply this Roman watermill turned upside down, sails put on in place of the water wheel, and provision made to face the sails round into the wind from whatever direction it blows. The first mills were used for grinding corn, and it was not until the 15th century that wind power was used by the Dutch for raising water and draining the land. Involving the use of two right-angle drives, top and bottom, with a vertical shaft connecting the two, this opened up the way to advances in gear drives which made possible the use of wind power for many different processes.

Wind power continued to be of great economic importance in the West, in places where water power was not available, until the advent successively of steam, oil and electric power; and for the last 60 years attempts have been made to generate electricity by wind. These electrical generators have evolved to a type resembling an aeroplane propeller, and although those of a larger size have still to prove themselves, the use of smaller units is widespread in areas untouched by electric power lines.

In the Netherlands, the first old-fashioned type of windmill to generate electricity is operating at Werbershoof, where an asynchronous motor is used to drive the mill through a gear incorporating an overrunning clutch. When the mill overruns the motor and drives it, the power generated is pumped into the low-tension side of the grid.

The disadvantage of this mill was that the sails were cloth-spread and reefed by hand, and the cap of the mill carrying the sails also had to be turned by hand with each change of wind. Recently the cloth-spread sails have been changed to shuttered sails, invented in England in 1807, which are remotely controlled and automatic, but are nowadays constructed of steel and aluminium with aerofoils and flaps on the leading edges.

De Kraai windmill, at Westbroek near Utrecht, has been equipped for electrical generation. The mill is servo-controlled, eliminating the need for constant supervision and increasing its availability.

In the servo-controlled de Kraai mill, the need for constant supervision is obviated, and the availability of the mill is increased. It will be interesting to learn the economics of this adaptation when it has been running long enough to assess them.

The work has been carried out to the instructions of Stichting Electriciteits Opwekking Door Windmolens of Hilversum by Mr. Christiaan Bremer of Adorp, who is at present repairing the windmill at Cranbrook, Kent, for the Society for the Protection of Ancient Buildings and the Kent County Council. This work is referred to in a note on the facing page.

The accompanying illustration of de Kraai mill is reproduced from a Royal Netherlands Tourist Association photograph.

In Parliament

WORK STUDYING THE RAF

Methods being taken to achieve a more efficient use of manpower in the Royal Air Force were considered in the House of Commons last week as the result of a question by Mr. Geoffrey de Freitas (Labour). He said he wondered whether the setting up of the Directorate of Work Study at the Air Ministry had not caused other senior officers and heads of departments to feel that a saving of manpower was not one of their primary responsibilities in their own branches of the Service.

Mr. C. I. Orr-Ewing, the Under-Secretary of State to the Air Ministry, said that the Ministry's work study resources had been deployed during recent months on a wide range of studies, covering the operational, technical and administrative spheres of the RAF. Their activities included a review of technical trade groups to produce a higher degree of flexibility, and thereby a fuller utilisation of time and skill. Such a result was especially relevant in those trades where shortages were expected when national service ended.

Other studies included experiments to improve and speed up the servicing of particular types of aircraft and the improvement of systems of supply. With the re-equipment and re-shaping of the RAF, it was difficult to isolate manpower savings due directly to work study. The value of the work to date was illustrated by economies achieved, for example, in the Air Movements and Stock Control Sections and at an important Signals Centre. As to the work of senior officers, the establishment committees went on with their normal work of trying to prune the establishments and to make sure that everyone was essential. Those efforts were quite outside the terms of reference of the Ministry's work study group.

MOTORWAYS TRAFFIC REGULATIONS

Two statutory instruments were laid before parliament by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation; one varying the classes of traffic authorised to use the new motorways, and the other varying for special roads the speed limits applicable to certain classes of vehicles. He said that both sets of regulations had been set to expire in a year's time, in order to ensure that full consideration was given to the experience gained on the Preston By-pass before the first long motorway, from London to Birmingham, was brought into operation.

The proposals for regulating this traffic would comprise provisions for excluding from the new roads motor cycles of less than 50 c.c. capacity, certain special types (such as vehicular agricultural machinery), and vehicles for the transport of abnormal indivisible loads, other than vehicles used for defence purposes; provisions covering the conduct of drivers and pedestrians; and the framing of a new motorway code. It was proposed that motor vehicles drawing trailers (not being articulated vehicles) would be subject to a speed limit of 40 m.p.h., if the trailer had less than four wheels or was a close-coupled four-wheeled trailer. With that exception, however, no speed limit applicable generally to any class of vehicle would apply on the new motorways. In regard to these proposed regulations, it had to be borne in mind that there was no experience of any kind in this country in relation to roads of this character.

What happened in the United States and elsewhere was not necessarily a fair yard-stick to apply to conditions in Britain. It would be best, he told Mr. R. Gresham Cooke (Conservative) to try out these regulations, including that providing for the exclusion of vehicles transporting abnormal indivisible loads, and to learn by the results.

ROADS OVER RAILWAYS

Sir Alfred Bossom, Bt. (Conservative) asked the Minister of Transport and Civil Aviation whether, in view of the increasing traffic congestion in the approaches to many cities in Great Britain, he would authorise the construction of overhead roadways above the existing main-line railways, together with the necessary approaches and flyovers. Such arrangements, he considered, would avoid the greater expense which might be required in the future if provisions of that kind were not made very shortly. Mr. Harold Watkinson replied that the possibility of building over existing railways would be taken into consideration when proposals for new or improved roads were examined. So far, other methods of road construction had proved to be more practical, but he would continue to keep the idea in mind when considering future road schemes.

UNREMUNERATIVE RAILWAYS

A number of other transport matters were discussed. On the question of what was to be done in connection with unremunerative railway lines, Mr. Harold Watkinson told Mr. Geoffrey Wilson (Conservative) that the railways were no longer a monopolistic organisation, with an obligation to provide a service for all sections of the community.

He said that he had met the chairmen of the transport users' consultative committees on 24 June, and had informed them that the Government intended to strongly support the British Transport Commission's plans for eliminating those services which were hopelessly uneconomic under modern transport conditions. The consultative committees, when considering proposed withdrawals, would continue to give full opportunity to local interests to express their views, and, in making recommendations, the committees would continue to take into account the existence of alternative services and the need for them.

The Commission were under no obligation to provide an alternative service, but their chairman, Sir Brian Robertson, had assured him that they were willing to co-operate fully with the committees in exploring how the needs of those sections of the public affected by withdrawals could best be met. Mr. Watkinson said that he was only too conscious of the transport problems of rural areas and he was sure that the committees also were very well aware of them. The Commission did not advocate removing services in cases where there was some hope of their eventually paying their way, or where they could provide necessary feeder services to other parts of the railway system. The Commission had to try to get their finances into order, and parliament must not stand unduly in their way in their efforts to cut their costs. At the present time, the Commission were being very heavily subsidised by the taxpayers.

AIRCRAFT NOISE

During his visit to America, Mr. Harold Watkinson said, he had had a most useful exchange of views with representatives of the Port of New York Authority regarding the problem of aircraft noise. These talks had followed discussions in London among officials of the Western European airport authorities. It seemed to be generally accepted, on the basis of information so far available, that unless there were further progress in engine silencing, the operations of large jet aircraft at airports in built-up areas would have to be somewhat restricted. Otherwise, they might cause considerable disturbance.

These restrictions, he told Mr. Frank Beswick (Labour/Co-operative) and Mr. John Rankin (Labour/Co-operative), would vary from place to place. In general, it had been agreed between the countries concerned that these aircraft should be tried out under normal passenger operating conditions at the larger airports, so that each authority could state what it felt were the minimum restrictions that would protect the interests of people residing round the airport.

BRITISH EXHIBITS AT BRUSSELS

Definite satisfaction was expressed by Dr. Charles Hill, the Chancellor of the Duchy of Lancaster, with the co-ordinated efforts made at the Brussels International Exhibition by the United Kingdom Government and British industry. He said that the great majority of the comments made by British and foreign visitors had been strikingly favourable, and that the Government's pavilion had been widely acclaimed as a most dignified and forceful presentation of British institutions and achievements. The number of visitors to the Government's pavilion, up to 16 July, had been over 1,791,000. The British Industry Pavilion was on a large scale and contained many striking exhibits. It was, he told Mr. Beresford Craddock (Conservative), a convincing presentation of this country's industrial and commercial vigour. He had visited the exhibition in mid-June and had seen for himself the excellence of the British pavilions. He congratulated and thanked all those who had been responsible for the design and construction of the Government's pavilion, and all those in industry and commerce who had contributed, at considerable expense, so effectively to the British Industry Pavilion.

Pneumoconiosis Among Coalminers

The Minister of Health was asked by Miss Jennie Lee (Labour) about the numbers of miners whose deaths were due to pneumoconiosis during recent years. She was told by Mr. Derek Walker-Smith that 1,020 men aged between 20 and 64 had died from that cause during the five-year period 1949 to 1953.

Canals and Waterways Report

It was announced by Mr. Harold Watkinson that the report of the Committee on Canals and Inland Waterways, presided over by Mr. Leslie Bowes, was being published on 28 July. No conclusions would be reached by the Government until interested parties had had an opportunity of examining that document, which went very thoroughly into all aspects of the waterways and made some far-reaching recommendations.

No Trade Fair for Hong Kong

Information was sought by Mr. S. O. Davies (Labour) from the Under-Secretary of State for the Colonies regarding the extent to which Britain was participating in the "International Commodities Exhibition" now being held in Hong Kong. In reply, Mr. John Profumo said that he understood the question to refer to an international trade fair which the Kowloon Chamber of Commerce was proposing to organise. Actually, neither the United Kingdom Government nor the Government of Hong Kong had been asked to participate and it was understood the proposal had been dropped.

CRANBROOK WINDMILL RESTORATION

The Union mill at Cranbrook, Kent, built in 1814 by James Humphrey, is 75 ft high, the tallest in Southern England and said to be the finest mill in the country. It stands on an octagonal base. In 1842 the original cloth sails were replaced by shuttered sweeps and winding gear. All the internal equipment survives and the exterior is now being repaired.

The mill was worked since 1832 by its owners, the Russell family, until 1953, by which time its sails had become unusable. To put the mill into repair, at a cost of some £3,000, a fund was started by the Society for the Protection of Ancient Buildings—and the work is now in hand under the direction of Mr. Christiaan Bremer and his brother Jacob, from the Netherlands. The Society still has to raise £1,800, and will welcome contributions to the Treasurer, The Windmill Fund, Westminster Bank, Cranbrook; or to the Hon. Secretary, the Windmill Section, Society for the Protection of Ancient Buildings, 55 Great Ormond Street, London, W.C.1.

Atomic Review

Active and Inert

MATERIALS employed in nuclear work are sometimes chosen because they are chemically active, but more often because they are chemically inert. In reactors, the coolants, moderators, canning and structural materials are required to be passive and compatible; therefore be expected that the total pumping power in an organic-cooled system will be considerably higher than that required for a pressurised-water system, though it would not be expected to approach that of a gas-cooled system. Offsetting this extra charge are the combined advantages that organic coolants are far less corrosive than pressurised water and require an over-pressure of only a few tens of lb per sq. in to prevent film or bulk boiling, as may be gathered from Fig. 2. These properties enable the use of common materials such as low thermal-neutron cross-section aluminium (and possibly zirconium) alloys for the pressure tubes of the core calandria and for the fuel-element cladding, and mild steel for out-of-pile applications other than the steam generator, in which it would be necessary to cater for the corrosion on the water side of the tubing: the use of monel metal is suggested. It would clearly be of considerable economic benefit to be able to fabricate circuit components such as pumps, valves and pipe couplings out of commonplace materials.

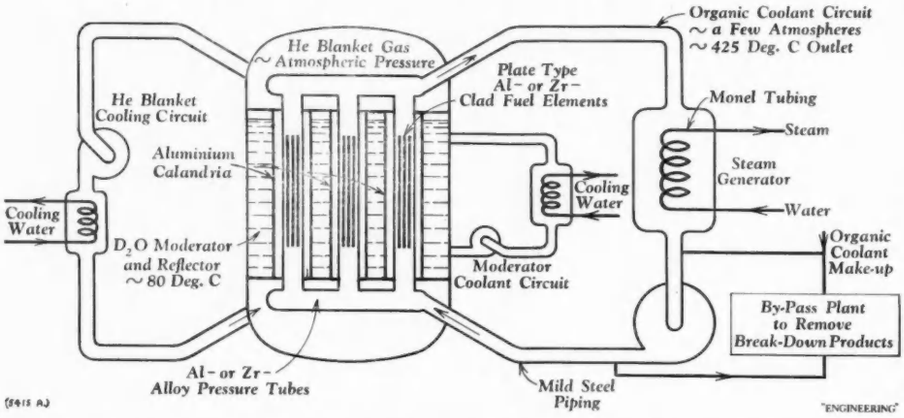


Fig. 1 Essential features of an organic-cooled heavy-water moderated power reactor scheme. Reactivity might be controlled by liquid moderator level.

while reagents used in processing nuclear fuels are essentially reactive. Materials of both kinds are considered in the following summaries, which are based on papers delivered at the Nuclear Engineering and Science Conference held in Chicago earlier this year.

Organic Coolant with Heavy-Water Moderator

A paper by Malcolm J. McNelly, "Some Aspects of the Use of an Organic Coolant in a Heavy-Water-Moderated Power Reactor," reviews many of the main factors involved in designing a fairly compact reactor of this kind, the general arrangement of which is shown in Fig. 1. The reactor is intended to burn natural or very slightly enriched uranium (or possibly re-cycled plutonium-enriched uranium) and yet also be capable of providing a relatively high outlet temperature without the use of extreme coolant pressures as would be necessary for efficient water or gas cooling. The main obstacle in this scheme seems to be the combination of radiolytic and pyrolytic decomposition of the organic coolant; and among other things the paper seeks to show by the use of data from numerous sources that this difficulty can be overcome.

Heavy-water as a moderator need not represent a prohibitive capital interest charge against the power generated, amounting to perhaps 0·3 mill per kWh in 6 to 10 mills per kWh total, but if it is also used as the coolant in a high-pressure high-temperature heat-transfer system, not only is there a considerable investment in the cooling system, but also there are inevitable leakage losses which would be very costly to accept or prevent. Attainable reactor outlet temperatures are limited by the thermodynamic properties of water and circuit engineering to about 300° C, whereas the use of cheap polyphenyl mixtures (mainly diphenyl and terphenyl) enables outlet temperatures of about 425° C to be realised without serious fouling of heat transfer surfaces or excessive and uneconomic destruction of coolant material. This compares with outlet temperatures of just over 500° C considered in sodium-cooled and bismuth-cooled systems.

The heat transfer coefficient for diphenyl is reported to be about one-fifth that of water flowing under the same conditions. Moreover, the increase of viscosity consequent upon operation at an equilibrium concentration of decomposed coolant "tars" results in a further increase of coolant pumping power, and it may

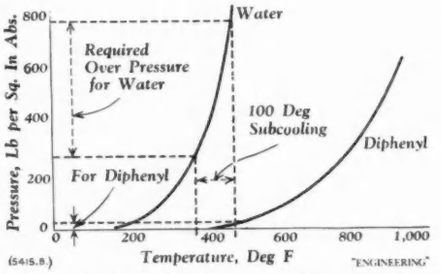


Fig. 2 Over-pressure required for sub-cooling with water and diphenyl, a comparison of importance in organic cooled reactor design.

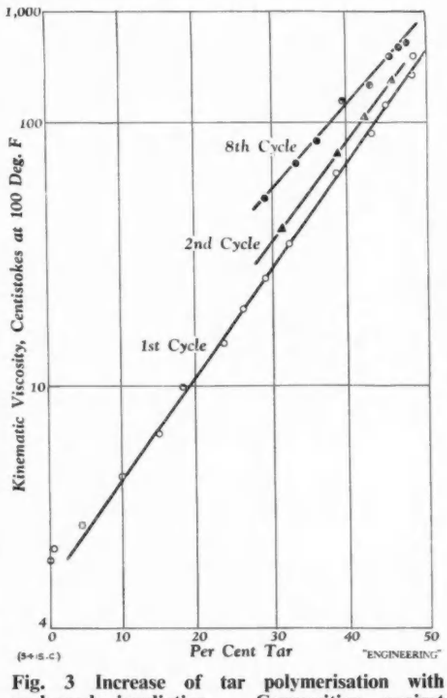


Fig. 3 Increase of tar polymerisation with prolonged irradiation. Composition against viscosity.

Primary Circuit Shielding

The radiation shielding of the primary coolant circuit would not be a major consideration because the coolant itself would not become significantly radioactive, but some attention has to be given to shielding on account of the probability that some activated particulate matter might well appear in the coolant fluid, including, in particular, the reaction products from a burst fuel element. The hazard from burst fuel elements could be reduced to very small proportions by the use of oxide fuel dispersed in an aluminium material and bonded to the aluminium cladding, but this would be a costly method of manufacture, mainly applicable to enriched fuel, and the authors prefer to consider the use of natural or near natural uranium metal with suitable surface treatment to prevent the uranium fuel reacting chemically with the aluminium can. In the event of exposure of the uranium to the coolant, the dissolved radiolytic hydrogen would react with any exposed uranium metal, but if the hydrogen concentration is kept sufficiently low by appropriate continuous treatment of the coolant, the corrosion rate of uranium metal exposed to organic coolants is very low, less than 1 mill per year at 425° C being quoted.

In order to achieve high thermal rating of the fuel, fairly thin section flat-plate fuel elements similar to the now familiar MTR configuration are preferred, but it is desirable when using natural uranium fuel to keep the surface-to-volume ratio of the fuel material to a minimum in order to increase the resonance escape probability as much as practicable. Therefore the sub-

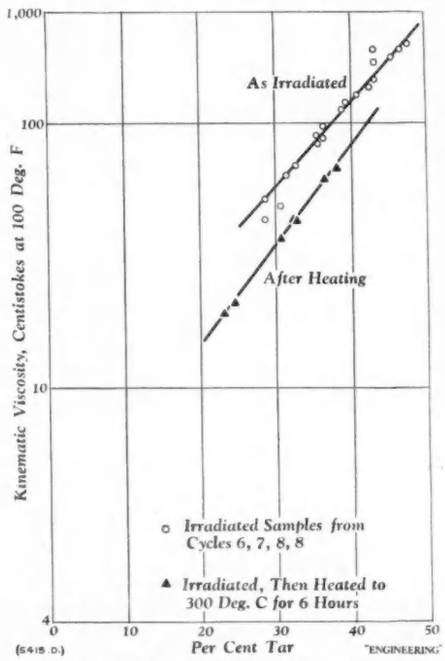


Fig. 4 Reduction in viscosity of low temperature irradiated coolant on subsequent heating.

division of the fuel in each fuel cluster (that is in each coolant-channel) will be kept to the minimum consistent with not exceeding the uranium phase transition temperature of 660° C in the centre of the fuel material. The coolant channels will also be kept as narrow as possible to reduce neutron absorption in the coolant to a minimum and to retain as much self-screening within the cluster as practicable in order to off-set as far as possible the effect of fuel element sub-division upon resonance capture.

Coolant Stability

The requirement for narrow cooling channels, fast coolant speeds and high heat and radiation fluxes at high temperatures naturally focuses attention upon the stability of the organic coolants against pyrolytic and radiolytic damage. It appears that the cheapest of the polyphenyl materials, a mixture of diphenyl and terphenyl, is also the most resistant to the in-pile conditions, the effects of which are to form polymers of higher molecular weight, a certain quantity of more volatile hydrocarbons and a good deal of hydrogen gas.

An important general conclusion from a considerable body of experimental data is that the amount of radiation damage produced is largely independent of the temperature level, a conclusion which has led to an interesting method of investigating the relationship between radiolytic and pyrolytic damage which has been developed at Hanford and described by D. R. de Halas, also of the General Electric Company, and described in his paper, "Radiolytic and Pyrolytic Decomposition of Organic Reactor Coolants." In these experiments the organic under test was circulated through a nuclear reactor in aluminium tubes at a temperature just below that of boiling water (94° C), at which low temperature the pyrolytic decomposition is negligible. The amount of radiolytic (or total) decomposition is measured by distilling off (at reduced pressure) the original polyphenyl from a sample and measuring the quantity of residual tar. The tar-content alone, however, is not sufficient to form a complete assessment of the effects of irradiation, and therefore the viscosity of the irradiated coolant is also measured. It seems to be fairly well established that a given coolant containing a certain tar fraction is more viscous the higher the molecular weights of the contained tars, and that therefore graphs of tar fraction plotted against viscosity give an indication of the transformation of the tars during the irradiation process. A representative set of results is shown in Fig. 3, in which at each successive cycle of irradiation a fraction of the total batch of circulating coolant was replaced by fresh coolant, leaving a portion only of the tars from previous cycles to undergo further irradiation. This is similar to the state of affairs which would occur in an operating reactor in which the coolant would be reconditioned on a continuous by-pass or by a batch process.

When samples of the coolant which had been irradiated at low temperature (below 100° C) were subsequently heated to temperatures exceeding about 120° C, the coolant underwent a considerable permanent reduction in viscosity as measured under the standard viscosity measurement temperature, indicating that the higher polymers formed by the irradiation process had been degraded by heating, resulting in a reduction of both viscosity and (as shown by separate measurement) of tar content (see Fig. 4).

The author's investigations demonstrated the existence of first-order rate laws for both radiolytic and pyrolytic decomposition treated as isolated phenomena (that is the rate is proportional to the amount of undecomposed organic coolant remaining and is not affected by the presence of the tars and other products). For the radiation damage:

$$f = 1 - \exp(-w\,k\,r/W)$$

where

f = tar content fractional weight
w = weight of coolant in radiation flux (neutrons)
W = total weight of coolant in circuit.
r = total dose of epithermal neutron flux (nvt)
k = rate constant, sq. cm per neutron, of order 10^{-18} for substances tested.

In the experiments the neutron dosage received by the coolant was measured by using bare cobalt foils (of cobalt-aluminium alloy) attached to the coolant tubes, the corresponding epithermal neutron flux being assessed from cadmium ratio measurements. It is the epithermal flux which is the important factor in these measurements since the high energy neutrons cause the most damage to the chemical molecule.

The rate-laws for the combined effects of pyrolytic and radiolytic damage (see Figs. 5 and 6) are somewhat more complicated, since the various polymerisation and degradation processes compete with each other, but the authors demonstrate a combined law which accords with a set of measurements of radiation damage made at a number of different temperatures, and go on to show how the maximum utilisable temperature may be determined from separate measurements, as indicated in Fig. 7, of radiolytic and pyrolytic damage, only one or two measurements at low temperature being required in the case of the more difficult radiolytic damage measurement. For the experimental material, monoisopropylbiphenyl (MIPB) the upper limit appears to be about 425°C.

Plutonium Reactor Physics Considerations

The physics of this general class of reactor is being closely investigated by the Hanford Laboratories (also operated by the General Electric Company), and ideas concerning an integrated engineering and physics study of the problem of burning plutonium-based fuels are reported in a paper by J. R. Triplett. For these studies a heavy-water cooled, heavy-water moderated reactor (Plutonium Re-cycle Programme Reactor, PRPR) has been chosen on the grounds that it provides a very flexible experimental facility which has valuable inherent safety characteristics particularly in regard to the relatively minor effect upon reactivity of an accidental loss of heavy-water coolant.

Nevertheless, organic coolant is an alternative proposition which has been kept under consideration. The loss of a hydrogenous coolant would, under certain conditions of moderation, introduce more reactivity through the removal of neutron absorber (the hydrogen in the organic) from the core than was lost through the loss of the moderating effect of the same hydrogen. Therefore it was decided to use heavy water rather than a hydrogenous fluid for the coolant in this flexible experimental facility in which the degree of moderation is variable by adjusting the fuel grading. However, in a power reactor burning plutonium (and converting fertile uranium 238 into more plutonium) it is probable that the reactor would operate somewhat undermoderated to provide the optimum conversion ratio, in which case the coolant loss hazard might be eliminated from the system.

One interesting point concerning a plutonium-fuelled heavy-water-moderated reactor arises in connection with its kinetics. It is found (by calculation) that the deficiency in delayed neutron production from plutonium fission (as compared with uranium 235 fission) is compensated for by the production of delayed photoneutrons from the heavy-water by the gamma-ray activity.

Some interesting conclusions arise from the author's studies upon the plutonium re-cycling problem itself, in which use has been made of high-speed computers for the analytical work. One conclusion is that it is advantageous to the achievement of long irradiation of the fuel to keep the moderator as cool as possible; another is that for small sized reactors (which lose a large proportion of neutrons by leakage), the neutron spectrum should be well thermalised for maximum irradiation time in order to maintain reactivity as long as possible, whereas in large reactors (with low neutron leakage) an undermoderated spectrum is advantageous since the conversion ratio is of dominant importance in

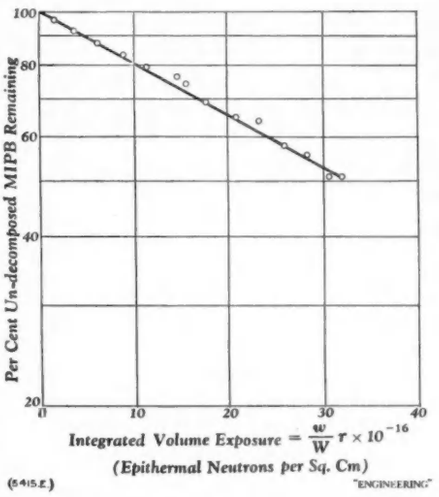


Fig. 5 Radiolytic decomposition of monoisopropylbiphenyl (MIPB), in absence of pyrolytic effects.

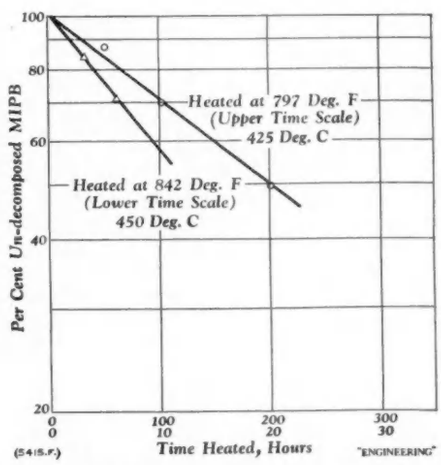


Fig. 6 Pyrolytic decomposition of MIPB in absence of radiation effects.

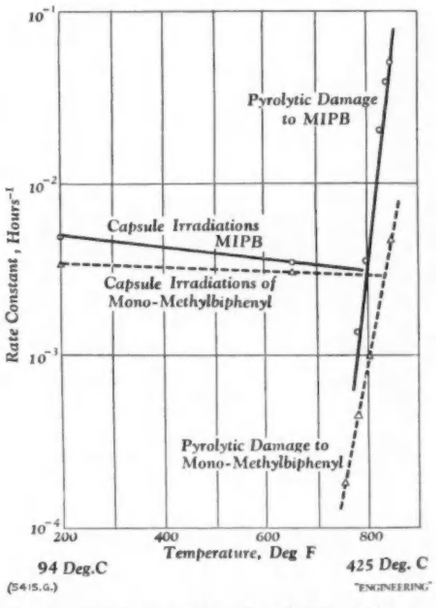


Fig. 7 Separate effects of radiolytic and pyrolytic damage for use in determining upper operating temperature limits.

Continuing Atomic Review

TABLE I.—*Cost of Enriching Spent Uranium*

Possible costs for re-enrichment from 2·0 per cent enriched uranium to 3·0 per cent enriched uranium			Possible costs for blending highly enriched uranium with 2·0 per cent enriched uranium to obtain 3·0 per cent enriched uranium		
	Dol per kg	Dol per g		Dol per kg	Dol per g
Value of 3 per cent enriched U	375·50		Cost of 10 grams of U235	171·00	17·10
Value of 2 per cent enriched U	220·00		Conversion—Nitrate to oxide	10·00	1·00
Difference	155·50	15·55	Loss during conversion	2·20	0·22
Conversion—Nitrate to UF_6	10·00	1·00			
Loss during conversion	2·20	0·22			
Conversion—UF_6 to UO_2	10·00	1·00	Conversion—UF_6 to UO_2	3·30	0·33
Loss during conversion	3·76	0·38	Loss during conversion	1·71	0·17
Totals	181·46	18·15		188·21	18·82

this case and the production of new plutonium is sufficiently large to off-set the burn-up of original plutonium and/or uranium 235 content in the fuel charge.

Re-processing and Re-enrichment

Although there is a school of thought which considers it might be economic to burn natural uranium fuel and to throw away the "ashes" without further treatment (at a disposal cost of between 0·1 and 0·3 mills per kWh) the balance of opinion seems to consider that some form of chemical re-processing of irradiated fuel is an essential feature of an economic power reactor system. With this question of re-processing is closely associated the problems of initial "enrichment" of the natural uranium, either with uranium 235 or, when the techniques have been developed, plutonium. Critical size and long-term reactivity considerations may influence capital costs to such an extent as to make it more economical to use slightly enriched fuel as the reactor working material in any type of heavy-water power reactor, and this is even more likely to be so in the case where a hydrogenous (for example, organic) coolant is used in pressure-tubes than in a heavy-water-cooled pressurised-water reactor, on account of increased neutron absorption.

The paper "Blending versus Re-enrichment for Slightly Enriched Uranium," by D. Kallman and J. E. Brennan (of Babcock and Wilcox) considers the relative merits of either re-enriching the spent uranium (in a diffusion plant) or blending highly enriched uranium with the spent (or original natural) uranium in order to produce the low-enrichment fuel required for many power reactor projects.

The authors considered that, in view of the uncertainty of the costs of the chemical processes involved in the two routes to re-enriched fuel, there is little to choose between re-enrichment and blending on grounds of costs, and that the presence of uranium 236 in the re-cycled uranium may become a serious disadvantage in view of the fact that this will be concentrated (to a slightly less extent) along with the uranium 235 in the diffusion plant process. In view of the greater flexibility of the blending process, therefore, the authors conclude that blending is to be preferred as the working practice.

The author of the paper "General Economics of Chemical Re-processing Using Solvent Extraction Processing" (F. L. Culler of ORNL) concludes that the value of residual uranium and plutonium in irradiated natural and partially enriched fuel will probably always exceed the recovery costs, provided the chemical processing is carried out in large chemical plants which deal with the output of some twenty 500 MW (electrical) reactor plants situated within about 1,000 miles radius of the processing plant. This assumes that 4,000 MW days (heat) per ton of natural uranium are extracted from the fuel and that it is required to keep processing charges down to about 0·75 mill per kWh electricity; a necessary objective if electricity is to be sold at 8 mills per kWh, the price of coal-produced power in the United States, from plants costing 250 dol per installed kW. It is interesting to note the estimate of up to 0·2 mill kWh for irradiated fuel transportation costs: this may be compared with the 0·3 mill per kWh estimated for the heavy-water interest charge in the paper by M. J. McNelly.

Notes and News

British Industry at Geneva

An industrial exhibition of nuclear engineering will be held in the Palais des Expositions, Geneva, at the same time as the Second United Nation's Conference on the Peaceful Uses of Atomic Energy (1-14 September, 1958). The British section, covering 40,000 sq. ft, will form the largest national display. About 83 British firms will show exhibits that cover the whole field of the peaceful applications of nuclear energy. In addition to this opportunity of examining what Great Britain has for sale, participants in the concurrent U.N. Conference will be able to read 45 papers contributed by British manufacturers (some jointly with the UKAEA), and to meet 52 advisors drawn from the British manufacturing industry who will support the British delegation to the conference. The Nuclear Energy Trade Association's Conference (NETAC) is the sponsor and co-ordinator of the British section.

Models of power stations and research reactors will be shown, and examples of the electronic instrumentation connected with reactor control will be seen. As Britain is a major world supplier of radioisotopes, many examples of their use will be demonstrated; in addition equipment will be shown for their production. Another exhibit will display the manufacture of stable isotopes of boron, carbon, nitrogen, and oxygen, while models of electron linear accelerators will be used to illustrate irradiation experiments.

As is well known, Britain has based her power programme on the gas-cooled graphite-moderated reactor using natural uranium fuel. But one of the British exhibits will be a model of a boiling water reactor, another will deal with test plants for metal to steam heat transfer and designs for a pressurised water reactor, and a third will show a heavy-water production plant. There will be models of the reactors NEPTUNE and DIDO.

As nuclear engineering calls mainly for new applications of well-known engineering principles, there will be many exhibits in the British section that are of conventional design, such as pumps, valves, and filters, but manufactured to unusually close tolerances. A multi-ratio gear-box for experimental reactor control will be shown and so also will new welding techniques developed to meet the special exigencies of reactor and power station construction. Finned fuel-element cans made of special alloys, heat-exchanger tubes of many types, and wrought or fabricated products from metals such as zirconium, titanium, tantalum, beryllium, niobium, and vanadium will feature in the metallurgical displays. Methods of isotope production will be demonstrated, including electromagnetic separation. One firm will be showing aluminium reactor core tanks and alloy steel castings, as well as specimen welds for various thicknesses of metals up to 4·5 in aluminium.

The production of radiation-resistant lubricants and pumps for circulating radio-active gases at high temperatures and pressures will be among the other subjects dealt with.

Dounreay Fast Reactor Critical 1959

The fast breeder reactor experiment, Dounreay, is not expected to go critical until spring or summer 1959. When it does, it will operate for some time at low power. The diversion of effort necessitated by the Windscale accident, together with certain modifications to equipment within the biological shield, are mentioned in the Fourth Annual Report of the United Kingdom Atomic Energy Authority as causing the delay. As a result of a final reappraisal of the whole reactor, quite a number of minor modifications have been carried out, and some alterations have been made to the bottoms of the cartridges.

All the civil engineering work and the major mechanical construction in the reactor building were completed within the period covered by the report (1 April 1957—31 March 1958). The steel containing sphere was successfully pressure tested, and the rotating shields on top of the pressure vessel, which allow the charge-discharge machine to be located over every individual fuel channel, and the main seals associated with the reactor vessel, passed their operational tests. Pipework and pressure vessels of both primary and secondary liquid-metal coolant circuits have been erected, and were undergoing pressure and leak tests. The heat exchanger equipment was completed, apart from some electrical wiring, and has been tested. Several of the diesel-driven generator sets have been commissioned. Construction and erection work on the turbine house was in line with the programme, and the sea-water pump house, with its associated mains, has been commissioned.

The Fleck Committee on the organisation of the industrial group recommended that the staffing of existing production facilities should be strengthened, if necessary at the cost of concentrating the Authority's future development programme on fewer projects. As the fast reactor is a relatively long-term project, its priority is lower than those projects more immediately concerned with the nuclear power programme. In particular, the Materials Testing Reactor at Dounreay is a much more urgent requirement, and, consequently, the diversion of the operating staff there has made the commissioning period of the fast reactor longer than was planned.

The Human Element

Council for the Bulge

The problem of making the best use of young people during what may prove to be a period of considerable over-supply—the coming " bulge " in school leavers—is to be considered by a newly established Industrial Training Council. It was set up as a result of a recommendation by the sub-committee of the National Joint Advisory Council on the recruitment and training of young workers in industry. The I.T.C. comprises eight members, representing the British Employers' Confederation and the Trades Union Congress, and three of nationalised industry; in addition, the Ministries of Labour and of Education, the Scottish Education Department, the Association of Technical Institutions and the City and Guilds of London Institute, have each been invited to appoint a representative to participate in the council's work.

Lord McCorquodale, who was elected chairman of the Council, said that their primary job would be to try to ensure that industry's training arrangements were adequate to enable the best use to be made of young people. Their aims and objects are " to keep under review the recruitment and training of work people, to provide encouragement and help to industries in dealing with the training of work people, and to collect and disseminate information about aspects of training common to more than one industry, including information about training practices in other countries." The composition of the Council—leading figures from both sides of industry, including many who have shown a keen interest in such problems over a long period—should ensure that the Council's lead is an authoritative one.

Strike While the Iron Cools

In 1957 the working population declined by 61,000. This occurred when wage rates were still increasing and in a year that saw wage rises go to over 12 million workers—half the working population. It was indeed a peak year for labour and may yet have been a record year of progress for some time.

There were however 8 million working days lost and this was the worst result recorded for over thirty years. The key to these conflicting statistics is the gradually stiffening attitude of the employers to higher wages—an attitude which has been even further marked in 1958 and which may produce in its turn similar statistics of an even more emphatic kind.

The lesson of the 1957 figures is that workers will strike for rises even towards the end of an industrial boom and that they will meet with a fair amount of success.

The lesson of 1958 is likely to be that even when the iron begins to cool they may go on striking or threatening to strike, and that the public will let them. But already, as in the case of the bus strike, it becomes more difficult to make an impression.

Tools for Teaching Science

An attempt to assess the extent and nature of science teaching in grammar schools and large direct-grant schools, and facilities available for it, was made by way of a questionnaire sent out to 2,000 schools in May last year. Replies were received from 566 schools and the analysis of the results confined to 472, including 36 direct grant and 23 independent schools (in each case of over 300 pupils). The inquiry was undertaken jointly by the Science Masters' Association, the Association of Women Science Teachers and the National Union of Teachers.

The results of the questionnaire were analysed into statistical tables (the replies to each of 11 separate questions) and discussed in an article entitled " Provision and Maintenance of Laboratories in Grammar Schools " published in the June issue of *The Science School Review*. The questions dealt with the provision of laboratories, of laboratory technicians and the expenditure on equipment and supplies. The interest of the replies lies principally in the deficiencies that are revealed. If it can be assumed that the majority of the schools which did not reply (over 1,400) had even less to say for themselves, the situation of scientific teaching in grammar schools is truly deplorable.

The replies to every question suggest that considerable improvements could be made to yield a greatly increased supply of scientists. Girls' schools, states the article, could be a very important source of the increased number of scientists required in industry, in Government Departments, for teaching and for many other purposes. Only 39 to 47 per cent of girls in the sixth form take science, compared with between 61 and 66 per cent of boys. " We do not accept the conclusion," say the authors, " that women are scientifically less able and less educable than men." But a greater number of male scientists could also be produced given the necessary facilities. The whole survey suggests that the real obstacle to increased supplies of able scientists lies in the schools, not in the shortage of technical colleges.

Ethical or Practical

The July issue of the *Journal of the Engineers' Guild* sets out the arguments for and against the acceptance of the idea of collective bargaining for engineers as a professional body. It concludes by saying that the arguments for accepting the idea that engineers should embrace collective bargaining are mainly practical and the arguments against mainly ethical. It would probably be fair to say that the Guild's heart is with the ethical arguments and its interests with the practical ones. Whether one agrees with the conclusions or not the article is to be recommended as a fair exposition of the case on both sides of the argument.

The tide is with the realists. It is possible to quote the middle way as a means out of the difficulty for engineers—as the article does. One can point to the BMA as a professional body which has maintained professional integrity and yet acted as a negotiating body for the medical profession. It is arguable of course that the BMA is from this point of view doing no more than assisting at the interment of the professional man in a highly professional, decent sort of way.

Bargaining in Bundles

With the London bus strike behind us, and all that it meant, the idea of collective bargaining has once again come under fire. This is not so much because of reaction against the power of the trade unions in any political sense but because the would-be tidy minded think that certain basic principles in wage payments should be laid down. The cry has gone up once again that there ought to be some form of national wages policy and the call is as insistent on the left as it is on the right.

In a recent book, *National Wages Policies in War and Peace*, Mr. B. C. Roberts has set out the schemes operated in such countries as Sweden and Holland and shows that whatever they may have accomplished they have not achieved freedom from inflation. In the case of Holland, where a form of work study on a national scale was carried out after the war to fix relative wage rates, special conditions obtained after the Occupation. Since then the more inflexible features of the national plan have had to be modified. Mr. Roberts favours the de-centralisation of collective bargaining units, that is, their being broken down into smaller groups.

The question is one of great complexity. Technical people can quickly appreciate the value of having wage rates fixed according to some defined principles and in proportion to one another. But managements in engineering know better than most that employers cannot be easily persuaded to pay agreed rates when they can afford to bid up the price of labour. Those who talk of fixed rates and relationships strike at the root of trade union tradition. There are plenty of diagnoses but few acceptable prescriptions.

Working Through the Vac

Summer work for schoolboys and university students is much scarcer this year than at any time since the war and the rewards offered are tending to fall. Large numbers of young people have left for enforced " holidays " in the countryside or abroad with only slender hopes of finding a little jobbing work to keep themselves in funds. This new situation reflects the changed labour position in most industries. With unemployment around the half million mark and profit margins on the down-grade, employers are trying to get seasonal labour as cheaply as they can, and have become more " choosey."

The vacation work bureau of the National Union of Students are refusing to co-operate with firms imposing a colour bar. The bureau handles about 4,000 jobs a year and most of their applicants are coloured. According to the secretary, Mr. Bill Murray, nearly 99 per cent of the students who queue up, 50 or so strong, for work every morning at the office in Endsleigh Street are from Africa, the West Indies, and such places.

Students in Scotland are fighting back against low pay: they are reluctant to take on work unless the weekly pay is at least £7. A member of the Students' Representative Council's Employment Committee said that half the jobs offered had been refused because the pay was too low and made it impossible for the students to save. The better paid jobs were filled at once and could be filled many times over. Some kind of balance is likely to be established soon between supply and demand.

The Funny Side

The British Safety Council have taken to heart unfavourable comments on their safety posters with a horrific theme and have turned to what they call the " human humour approach." One general poster contains a series of eight cartoons illustrating the funny side of typical accidents, simply drawn in black and white and making the point most effectively. But in the right hand bottom corner, in dull grey, is a cartoon of three victims using an invalid chair, crutches and a stick. Two other posters have a more specialised application, one for electricians (" switch off and stay alive ") and another for builders (a fall from a defective ladder).

The first, almost instinctive, reaction of people to the sight of someone tripping up, or slipping or falling down clumsily is to laugh—until they see the extent of the injury. These posters take this up and will probably " get home " to most people, if only because they are amusing to look at and tend to be noticed rather than ignored.

This August the British Safety Council will be responsible for two of what they consider the most original " safety products " yet to be sponsored by them. The first is a coloured poster, produced in conjunction with Wolf Electric Tools Limited, entitled " Electric Tools Can't be Careless—But You Can." The second is a gramophone record—the British Safety Council's " Safety Sue." It is being released by Oriole Records and includes special verses " intoned by the Duke of Bedford, Donald Campbell, Denis Compton, Stirling Moss, Sheila Van Damm, and James (Mr. Safety) Tye."

Metals and Materials

RUBBER FOR ROADS, RAILWAYS AND BUILDINGS

As a result of the success of earlier experiments, the use of rubber powder and latex is finding increasing application in road-surfacing materials. An interesting development of 1957 was the announcement by the Road Research Laboratory authorities of interim results of the surface-dressing experiments laid in five different parts of England during 1955. On three of the roads which carried heavy traffic, the sections of surface dressing involving a normal " cut-back " bitumen " fatted " seriously during the very hot weather in the early summer of 1957, whereas the comparable sections of rubberised bitumen remained in good condition. " Cut-back " bitumen, it may be explained in passing, consists of a preparation of bitumen thinned down with a flux containing paraffin or a heavy fraction of petrol. After the laying of the road carpet, the flux evaporates leaving the asphaltic bitumen in close and intimate contact with the mineral aggregate of the carpet. " Fatting " is the name given to an undesirable condition in which the bitumen fraction rises to the road surface and makes it slippery.

The tendency at present is to use rubber in road conditions which are particularly severe and where traditional materials have proved inadequate. It is stated in the annual report for 1957 of the Natural Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3, that among the " difficult " surfaces so treated has been Spencer Street Bridge, Melbourne, a junction carrying heavy traffic, a cobbled hill having a 1 in 5 gradient in Pennsylvania, United States, a series of " dirt " roads in New Jersey and a number of country roads in other parts of the world, including some laid over peat foundations. In Australia, rubberised bitumen has had a thorough testing as a surface material for airport runways, with such good results, that more airports have been scheduled for the same treatment during the present year.

The Board is devoting considerable effort to the development of the applications of rubber in engineering and particularly good progress has been made in the use of rubber rail pads in permanent-way tracks. In South Africa, following a successful trial, 400,000 of these rubber pads have been ordered for use with concrete sleepers. In Australia, the New South Wales Railways are using regular supplies of the pads and intend gradually to introduce them into the majority of the track which they control. The Queensland Railways are to commence experiments with similar pads in connection with their electrification scheme, and there seems every prospect of the large-scale adoption of the pads by the New Zealand Railways.

The Board is also promoting the adoption of rubber in building operations by emphasising that the material may be used in connection with thermal insulation, anti-vibration mountings, and expansion joints. Other applications include rubber-based paints and adhesives, rubber crash doors, latex-foam and rubber floors, rubber sheeting for concrete finishes and duct formers.

RESEARCH ON STEEL CASTINGS

The use of oxygen, in quantity, in steelmaking operations is extending, and results from a programme of work carried out in the research station of the British Steel Castings Research Association, at East Bank Road, Sheffield, 2, in which oxygen was injected into a basic electric arc furnace, will be found of significance in steelworks laboratories and research centres. The investigation, of a type previously conducted in the foundries of member firms, has been carried out in the Association's graphite resistor rod furnace under conditions of more stringent control than was possible in production furnaces. It is stated in the Association's recently-issued fifth annual report that over 100 heats have been made during past year and a comparison of results between production furnaces and the Association's furnace has shown that the values of oxygen utilisation, measured in terms of " points " of carbon removed, per cu. ft of oxygen per ton of steel, and the overall efficiency measured in terms of " cumulative potential " were equally applicable in all cases. There is thus no scale effect.

A number of heats have been made employing abnormally high oxygen injection rates in order to generate fume, and quantitative data relating oxygen input rates to the density of the fume cloud have been obtained.

Trials have also been carried out with argon, polytetrafluoroethylene and a proprietary material producing carbon monoxide at liquid steel temperature, to test the efficiency of gas-flushing agents in removing hydrogen from molten steel in the ladle. The results have indicated that the removal of hydrogen by means of argon cannot be guaranteed if moisture is present, but that promising results have been obtained with the other media. It is known, however, that a definite hazard to health may arise from the use of polytetrafluoroethylene in certain circumstances.

Other researches in progress concern shell moulding, microporosity in steel castings, the efficiency of shot blasting, the efficacy of dust collectors, noise abatement in foundries and other subjects. The examination of moulding sands has been continued and it is announced that data sheets on a further 16 sands will be completed shortly and issued to members.

PLASTICS INSULATOR FOR PIPES

A flexible foamed-plastics material suitable for insulating hot or cold pipes has been developed by the Armstrong Cork Company Limited, Bush House, Aldwych, London, W.C.2. Made in sizes to fit any type of pipe from $\frac{3}{8}$ in to $3\frac{1}{2}$ in outside diameter, the covering is quickly applied; it can be either " sleeved on " or alternatively slit lengthwise for installations already erected, in which case the cut seam is re-sealed with an adhesive providing a moisture-proof joint.

Known as Armaflex, the material is suitable for use on copper tubing as well as on iron pipes and has a thermal conductivity of 0·28 B.t.u. at 75° F mean temperature. It is stated that a $\frac{1}{2}$ in wall thickness of the material will prevent condensation under normal conditions on indoor pipelines operating at temperatures as low as 32° F, while, under less severe conditions, a $\frac{3}{8}$ in wall thickness of the new material will prevent condensation on pipes of up to $2\frac{3}{8}$ in diameter. Armaflex will also withstand temperatures of up to 200° F.

Applied to indoor pipes the material does not require any finish but when exposed to the weather it should be protected in the same manner as is the case with other insulating compositions. The material, which can be supplied ready split for erection, if required, can be affixed to bends having an angle of up to 50° without the necessity for " mitreing."

GALVANISED STRIP FOR PACKING CASES

An electro-galvanised metal strip intended for box-strapping purposes is now being marketed by Package Sealing Company (Export) Limited, Uxbridge Road, Ealing, London, W.5. The new strip, which is supplied with a knurled edge, giving added grip-strength and hand safety for the user, is claimed to have many positive advantages over flat-band bright or " blue-metal " strip. It is stated that a patent Bonderising treatment is used in connection with the galvanising process and that not only is the strip rust-resistant but that the coating will not chip or flake under stress. Furthermore, it will retain its clean appearance and will have a longer working life than the normal metal strip.

The material is readily available in any size and thickness and in varying degrees of hardness. It is considered that it can be used for many manufacturing purposes other than the usual flat-band strapping of boxes, cases and cartons.

STANDARD BLACKHEART MALLEABLE IRON

Three grades of normal blackheart malleable iron castings, namely, B18/6, B20/10 and B22/14, form the subject of a new revision to British Standard 310, which covers these castings and was last revised in 1947. The figures: 18/6, 20/10 and 22/14 refer to the respective minimum tensile-strength and elongation values required on a 0·564 in diameter bar, in tons per sq. in, and percentages on 2 in.

The chemical composition of the metal of the castings is considered to be of less importance than the mechanical properties of the malleable castings. It is pointed out, therefore, that in the use of the Standard, compliance with the specified tests should be regarded as the main requirement indicative of the suitability of the material to perform its duty satisfactorily.

The provision and heat treatment of the test bars are specified, as are the tensile-test, bend-test and hardness-test requirements. Provision is also made for additional tests to be undertaken by arrangement with the manufacturer.

Alternative dimensions for the tensile test bars are given; these are based on practice in several other countries and they have been included in order to gain experience with them in the United Kingdom and to facilitate the exchange of information with other countries.

Copies of the standard may be obtained (price 4*s*. net) from the Sales Branch of the Institution, 2 Park Street, London, W.1.

ONE-COAT STOVING ENAMEL

A new one-coat paint finish for domestic equipment has been introduced by I.C.I. Limited Paints Division and has been given the name Dulux acrylic stoving enamel F 664-line. Based on acrylic resins, the enamel is stated to be particularly suitable for refrigerators, washing machines and other metal equipment used in kitchens and bathrooms. It possesses high resistance to yellowing and staining and has a high gloss. In appearance it is mid-way between vitreous enamel and an ordinary paint finish. The film thickness of the one-coat covering is about rather less than 0·002 in and the enamel can be applied to steel and electrolytically zinc-coated steel and aluminium, each of which, however, must be suitably pre-treated. A chemically clean and corrosion-free surface is essential before painting. Dipping or stoving primers can be supplied where necessary for covering surface imperfections.

Continuing **Metals and Materials**

STEEL TAKES TECHNICAL STOCK

For more than half a century technical progress in the iron and steel industry has been continuous, and at present the ferrous metals represent more than 90 per cent of the world's metal production. This development, on the whole, has been based on traditional methods and processes, which have been improved in efficiency and increased in scale to meet the more exacting specifications and provide the greater quantities demanded. To-day, it is clear that while established methods will continue to be used for a long time to come, far-reaching changes are possible in more than one branch of the iron and steel industry. Conditions vary in different parts of the world; an urgent need in one part may be a remote possibility in another, but changes are in the air, and they are no less interesting to engineers than to steelmakers. Engineers, particularly in the aeronautical and nuclear fields, have posed some difficult problems for the steelmakers, who, in turn, have found the engineers some interesting exercises in mechanical and electrical engineering design. As new processes are developed for iron and steel making, engineers will find in them both a challenge and an opportunity.

It was in the spirit of technical stocktaking that the Iron and Steel Institute held its special meeting in Belgium and Luxembourg from 18 to 28 June. The meeting, which was held jointly with the Journées Internationales de Sidérurgie 1958, at the invitation of the Belgian Centre National de Recherches Métallurgiques (CNRM), the Groupement des Industries Sidérurgiques Luxembourgeoises and the Groupement des Hauts Fourneaux et Aciéries Belges, had as its theme the study and discussion of new processes in iron and steel making.

Attended by representatives of 32 nations, the meeting opened in Liège, where the technical sessions were concerned with new developments in steelmaking, moved on to Luxembourg, where the technical papers dealt with new processes in ironmaking, and finished at Charleroi, with papers on the continuous casting of steel. There were 31 technical papers and 15 visits to works or research centres near to the three meeting places.

NEW WAYS OF MAKING STEEL

At the Liège session the emphasis was on pneumatic or converter methods. The Continental steel industry is based mainly on the Bessemer converter as its major steel producing unit, in contrast to the British industry, which is mainly dependent upon the open-hearth furnace, and much work has been done in recent years by Continental steel organisations to develop and improve the converter. It is well known that the Linzer Düsenverfahren or L-D process of blowing with oxygen was developed in Austria, and that it is in commercial use in several places. To this process are now added the German Rotor and the Swedish Kaldo methods of steel production, both of which use oxygen for blowing, but have rotating vessels instead of a Bessemer-type vessel of normal shape. Both methods of steelmaking are in commercial operation, and considerable operating data have been accumulated. It can be shown, for example, that both processes are capable of producing steels of very low residual element content, that they are economically advantageous, and can be used on all types of pig iron. An interesting possibility inherent in the new oxygen blowing processes is that of producing steel of any desired carbon content without recarburising. Oxygen-enriched blowing of orthodox converters is also widely practised, and delegates were able to see the process in operation at several plants, including five 50-ton converters at the Differdange, Luxembourg, works of the Société des Hauts Fourneaux et Aciéries de Differdange—St. Ingbert—Rumelange (HADIR).

Not all the proceedings were devoted to converters, however. The open-hearth furnace was also discussed, and compared in both capital costs and productivity with the alternative methods of steelmaking available. In first cost the large open-hearth furnace is at a disadvantage compared with the basic-Bessemer plant, but, against this, can be set the advantages of ease of control, flexibility and the possibility of increasing the driving rate to achieve the required production with fewer units. Oxygen can be, and is being, used for refining in the open hearth, but the availability of relatively cheap oxygen favours the pneumatic process.

A third process, electric-furnace steelmaking, is already a well-established competitor of both the older methods, and it is possible to foresee a time, not so far distant, when it will have overwhelming advantages in some circumstances. Fossil fuels, both oil and coal, while reasonably abundant at present in some parts of the world, will, of necessity, become scarce and more costly as time goes on. Electric furnaces are of great interest to steelmakers in localities where solid or liquid fuels are scarce. In Great Britain, where nuclear energy promises cheaper electricity, they are already finding an application outside the field of special alloy steel production in which they have been widely used for years.

DEVELOPMENTS IN IRONMAKING

Interest in new methods of ironmaking is stimulated by two main considerations—the need to reduce costs and increase outputs, and the fact that, in some parts of the world at least, raw materials suitable for use by traditional methods are either non-existent or becoming scarce. The technical sessions at Luxembourg dealt with both the adaptation of traditional methods to suit varying conditions and the use of entirely new processes.

Man's first production of iron was by the direct method, but more than four centuries ago it was superseded by the indirect process, which is the principal basis of steelmaking to-day. Nevertheless, interest in direct methods has never died out and in recent years the possibilities have widened. To convert ore first to iron and then, with the aid of massive and costly equipment, to decarburise the iron and so convert it to steel is a roundabout process which it is obviously desirable to short-circuit if possible; the difficulty in the past has been to do so consistently and economically. At present there are four processes in commercial operation, and others are in course of development. Of the latter an interesting example is the ORF process, being developed by the Ontario Research Foundation, for continuous production from concentrated ore of a hot sintered metallic cake which can be rolled directly to a usable sheet. The "Cyclosteel" process, of the British Iron and Steel Research Association, and certain others under development also appear to offer long-term possibilities.

But while the direct reduction processes may well become more common in the future, the iron and steel industry has to face the problem of using the conventional blast furnace more efficiently, with raw materials and fuel which are, in some parts of the world, of much lower grade than formerly. In such circumstances ore preparation becomes increasingly important. Ore bedding, beneficiation, sintering and the use of self-fluxing sinter are all practised widely, and must become of greater importance in the future.

Ore preparation to-day requires extensive equipment, and a single plant, under suitable conditions, may be made to serve more than one works. Such an arrangement was seen at the Terre Rouge, Luxembourg, works of the Aciéries Réunies de Burbach—Eich—Dudelange (ARBED). This plant has ore crushing and screening, sintering and nodulising equipment, which processes iron ore for the ARBED Belval and Esch works as well as for Terre Rouge.

Much work has also been done in recent years on improving the operation of the blast furnace itself, particularly in the matter of using oxygen and moisture in the blast, and in working with an increased top pressure, the latter arrangement making it possible to blow 5 to 7 per cent more air and increase the output in the same proportion, while retaining the same coke consumption rate and the same amount of dust at the offtake.

There are some raw materials which cannot be used readily in the conventional blast furnace, and the international experimental low-shaft furnace which was the subject of technical papers and was visited by delegates, is designed for experiments on such materials. The furnace, which is situated at the Ougrée works of the S.A. Cockerill-Ougrée near Liège, is somewhat similar to the conventional blast furnace, but is oval in cross section and has a charge height of only 16 ft above the tuyeres. It is used to study not only methods of utilising materials which are unsuitable for normal furnaces, but also new techniques.

CONTINUOUS CASTING OF STEEL

Continuous casting, the subject of the technical sessions at Charleroi, is another process which eliminates an intermediate stage in the production of certain types of steel product, and can therefore result in savings, both of capital and of operational costs. Because of its attractive possibilities the process has been, and is being, studied closely in several countries, and in a number of cases plants have been built to operate on a commercial or semi-commercial basis. Much work remains to be done, however, and delegates were able to see an experimental plant, operated by the CNRM at the works of the Aciéries et Minières de la Sambre, at Charleroi, which is designed for studying the continuous casting of killed basic Bessemer and electric carbon and low-alloy steels. A second unit now being built will be used for research on rimming basic Bessemer steel ingots and slabs.

Throughout the series of papers, discussions and works visits there was an underlying feature of considerable interest to engineers. It is obvious that however iron and steel making may develop in the future, electrical and mechanical engineers will become more and more involved, and will have to work in close co-operation with their metallurgical colleagues. More mechanisation, more automatic operation, and stricter control of many widely differing types of equipment are basic features which will be needed, whatever detailed form the plant and machinery of the future may take. Engineers and iron and steel makers have for long co-operated on a two-way basis; this association will become more solidly established as time goes on.

BETTER FILING

Tests have recently been carried out by two companies in the B.S.A. Group to determine the effect of treating the surface of hand files with colloidal molybdenum disulphide. The solution used was product No. 1127 of Acheson Colloids Limited, 18 Pall Mall, London S.W.1, in which the solvent is alcohol. The solution was diluted with toluene to enable it to be sprayed on the file. Treated files tested in a Herbert file testing machine gave up to 60 per cent better cutting performance; 12 in hand bastards removed 10·2 linear inches of 1 in square test bar (Brinell 187) as compared with 9·0 in for untreated files, and 12 in smooth removed 1·2 in as against 0·8 in in 30,000 strokes. Even greater improvements were obtained with "three square" files. The results showed that the improvement varied with the fineness of the teeth, and the action would therefore appear to be one of preventing clogging, the material acting as a parting agent. The coating also acts as a corrosion inhibitor and gives an improved appearance to the file.

Research and Development

THIN FILM LUBRICATION

1—Discharge Through Thin Oil Films

By C. Siripongse, M.SC., *P. R. Rogers*, B.SC., *and A. Cameron*, PH.D.

The voltage/current characteristics of thin oil films have been investigated. For normal oils the voltage drop across the oil film is independent of current above about ½ amp. This value is independent of viscosity and speed of the moving surfaces. It is sensitive to the amount of impurity in the oil, and very fine filtration causes the value to rise. For oils found in normal lubricating systems, the voltage/film-thickness constant is 4½ volts per 0·001 in.

One of the major difficulties in all work associated with the lubrication of heavily loaded contacts, which are found in many mechanisms such as gears, ball bearings, etc., is that it is very difficult to measure the oil-film thickness existing at the contact. The result has been that there have been a large number of opinions expressed about the conditions of the oil at this point. The remark of Merritt[1] 21 years ago at the General Discussion on Lubrication held by the Institution of Mechanical Engineers that "the precise behaviour of the oil film which separates gear teeth is not clearly understood" still sums up the present-day position.

It seems therefore that the prime necessity in a study of this class of lubrication is to find a way of measuring oil-film thickness which can be applied to all the various types of mechanism where thin-film friction is usually found. An excellent start on this problem has been published by Crook[2, 3] who measured the electrical capacity between rotating discs. This method naturally relies rather heavily on an accurate knowledge of the local geometry of the system and, therefore, is not applicable to more complicated systems such as gears.

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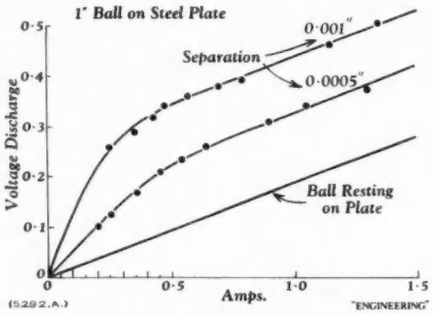


Fig. 1 Voltage/current characteristics of thin oil films: 1 in ball separated from oil-flooded steel plate, varying current being passed through both ball and plate.

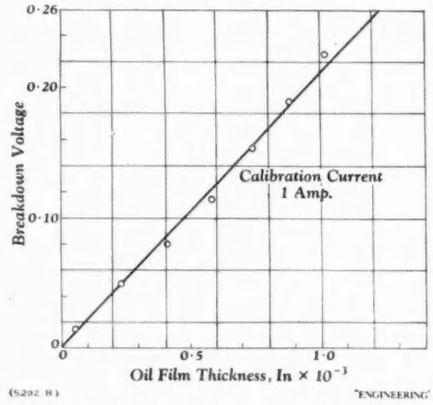


Fig. 2 Breakdown voltage variation with oil-film thickness.

It seemed that the work on the electrical properties of oil films described by Brix[4] and Cameron[5] could be developed into a suitable method. An extremely interesting paper, published by Beeck, Givens and Smith[6] had shown that the electrical conductivity of the film was related to the coefficient of friction. It was therefore considered that a systematic study of the electrical properties of these thin oil films would be valuable.

Brix, and also Cameron, showed that the voltage/current relations found when electricity passed through thin oil films were markedly different from the normal Ohm's law. When a current passed through a film the voltage potential across it increased to a fixed value which then remained steady up to a very large current. Cameron[5] reported experiments using currents up to 350 amps.

VOLTAGE/CURRENT CHARACTERISTIC

In these experiments a 1 in steel ball, with a flexible lead welded on to it, was placed on an insulated steel plate and both were connected electrically to a source of current. By varying the current the voltage drop was found to change proportionally in accordance with Ohm's law. If the plate was flooded with oil, and the ball separated from it by a small known distance, the voltage current curve changed markedly. Typical results are shown in Fig. 1. The bottom straight line is Ohm's law with the ball in contact with the plate. The other two curves are with the ball fixed 0·0005 in and 0·001 in away from it.

Presumably at very low currents it is possible to detect the Ohmic resistance of the oil film, though this was not attempted. Above ½ amp, on the other hand, the voltage curve runs parallel to the Ohmic line and it is assumed that this extends a considerable way, as shown in the previously published work. The distance between the curves and the Ohmic line is defined as the "discharge voltage." This voltage is independent of the current and corresponds to the potential difference required to maintain the discharge.

The voltage was found to be independent of the type of oil. A series of straight oils from S.A.E. 10 to S.A.E. 250, all from the same crude, were measured, and their discharge characteristics were the same to within about 5 per cent. This is not surprising, as it is assumed that the current is carried by ionised molecules and their characteristics should be independent of the molecular weight of the oil. It has been reported by Higham[7] that this discharge voltage is proportional to absolute pressure. Hence the voltage necessary to maintain the discharge increases with increasing pressure. This will be shown to be of considerable importance in interpreting the data from lubricated systems.

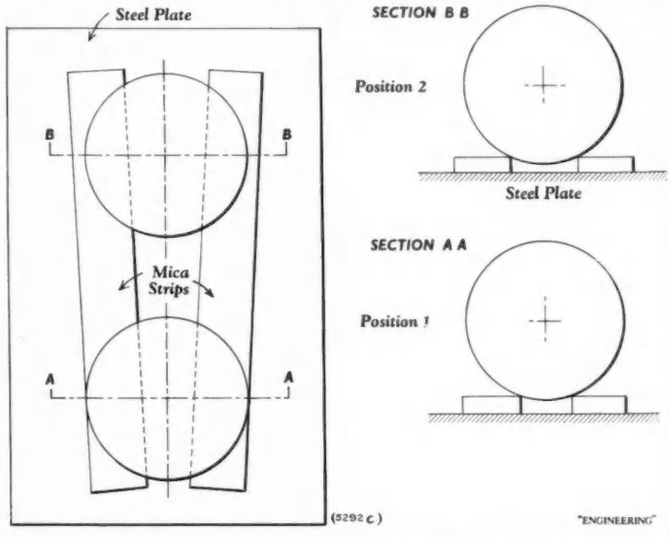


Fig. 3 Apparatus for obtaining very thin oil films of known thickness (static method).

If the discharge voltage is plotted against film gap the results shown in Fig. 2 are obtained, which indicate that the voltage is directly proportional to the gap. The very thin known oil-film thicknesses were obtained by sticking two thin strips of mica slightly diverging from each other on to the base plate. If the steel ball is placed between the strips when close together, and then gradually pushed down towards the wider end, it will approach nearer and nearer the plate, until it touches it (Fig. 3).

The oil-film thicknesses measured by these methods gave values which seemed very large. It was then suggested that this static method caused breakdown of the oil due to the continued passage of current through the same small volume of oil. The intense local field of force would also tend to attract any particles of dirt in the oil which would cause partial short-circuiting of the gap. This short-circuiting would of course be assisted by the decomposition products of the oil. For this reason methods were investigated for giving a dynamic calibration, whereby fresh oil was continually presented to the discharging surfaces.

The first attempt was to mount two steel balls on the anvil and screw of a micrometer, and direct a jet of oil at the gap. This showed very much higher values for the discharge-voltage/film-thickness figure. It was rather variable due to the difficulty of getting a reasonable oil flow through the very small gap, and also due to a certain amount of elastic distortion of the system. This confirmed that the static system was not suitable and led to the design of a method with a rotating shaft.

DYNAMIC CALIBRATION

The apparatus is shown diagrammatically in Fig. 4. It consists of a 1 in shaft against which are loaded very lightly two ¼ in plates. Their vertical position could be changed by using one of a number of fixing holes shown in the drawing.

Load was applied to the pads by pressurising

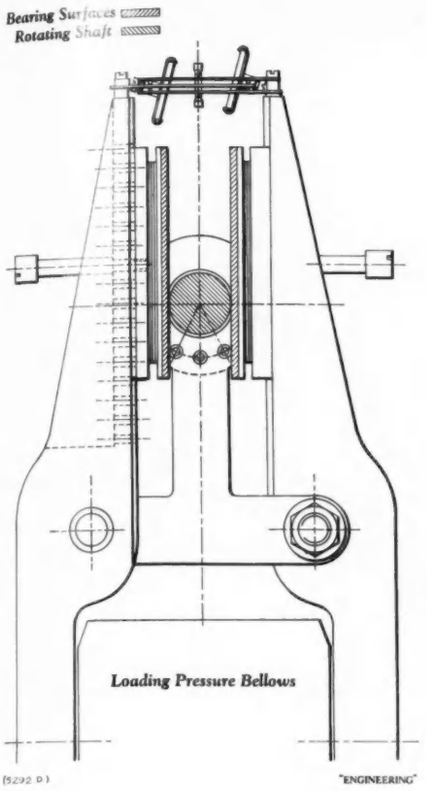


Fig. 4 (left) Apparatus for the dynamic calibration of thin oil films: 1 in shaft, bearing lightly on two ¼ in plates, adjustable for position and load.

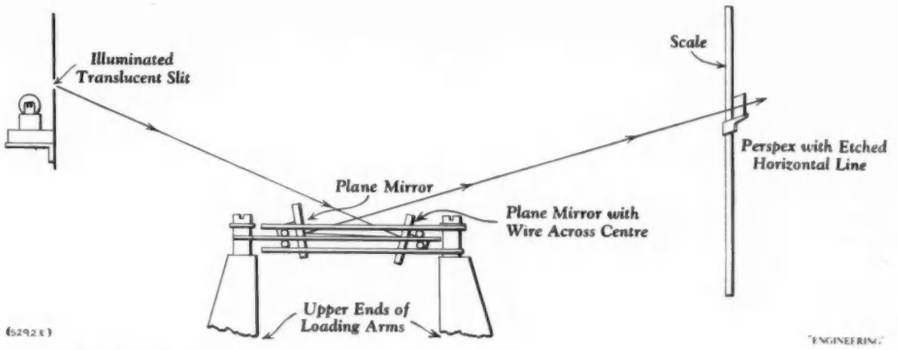


Fig. 5 (above) The optical measuring system of the dynamic calibration apparatus.

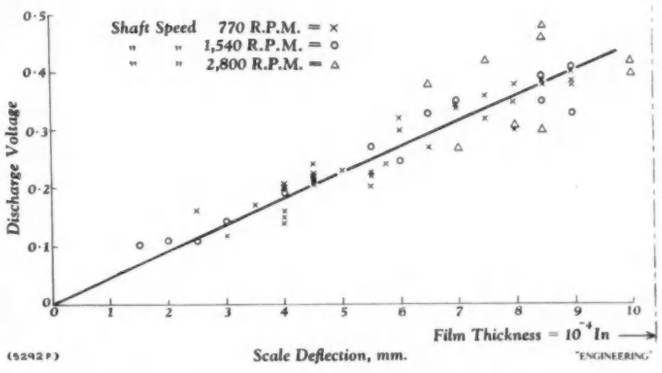


Fig. 6 (right) Discharge voltage plotted against scale deflection. (Oil temperature 17° C.)

a flexible steel bellows, through a simple pivoted nut-cracker lever. The film-measuring device consisted of a type of Lamb's extensometer attached to the upper ends of the two levers, the four main elements being an illuminated translucent slit, a plane mirror across which was a thin horizontal wire, another plane mirror and a piece of Perspex on which was a horizontally etched line, this being attached to the slider of a vertical tripod scale (Fig. 5). Due to inertia, vibration, ease of reading, etc., the maximum sensitivity of this system was limited to about 1 cm on the scale, equivalent to 10^{-4} in of oil-film thickness.

The principle of the system is that, when the bearing pads are loaded with the shaft stationary, there is no oil film between the components. When running under the same load there would be an increase in the distance between the two bearing surfaces which could be detected by the amount which the Perspex scale line had to be adjusted to bring into coincidence the translucent slit and the cross wire on the first mirror.

Fig. 6 shows the type of plot obtained from which two conclusions could be drawn: (*a*) the variation of dynamic breakdown voltage with film thickness may be assumed to be sensibly linear, and (*b*) variation in speed has little or no effect. From the test procedure it was also found that the effect of bearing load on the breakdown voltage was negligible; that the same calibration plots were obtainable with heavy or light loadings. No significant difference was found when brass plates were used instead of steel.

Very finely-filtered oil gave a higher value for the voltage/separation constant. In fact, the effect of particle size seemed to be of major importance in determining this constant. If the oil were very carefully filtered through an edgewise paper filter, the constant went up to 12 volts per 0·001 in. A considerable amount of attention is now being focused on this point.

If oil fresh from the drum was used, and then one part of tap water was well shaken up with ten parts of oil and allowed to settle out, no difference was found in the constant between the wet and dry oils. The value of the constant for the oil, which was not filtered, used in the tests described in the following article, was found to be 4½ volts per 0·001 in.

Work is now being carried out to attempt this calibration by a capacity method using a technique similar to that described by Crook.[3] Preliminary results are already available and they confirm the value already obtained of about 4 volts per 0·001 in.

2—*Lubrication of the Four Ball Machine*

By C. Siripongse, M.SC., *and A. Cameron*, PH.D.

A four-ball machine was studied, using the data obtained in the previous article. The shape of the voltage/current curves showed that a coherent oil film existed between the balls. Using the previous calibration, the mean viscosity of the fluid film could be determined, and the pressure required to give the viscosity so calculated was compared with the Hertzian pressure at various loads and speeds. The agreement was found to be satisfactory. The main features of frictional phenomena were thus explained using standard concepts. Further lines of research now being pursued are indicated.

Using the data obtained in the previous article, the electrical characteristics of a four-ball machine were studied. This machine was used for various reasons: it is cheap and easy to make; it has been shown that the results from it correlate as well as those of most other machines with actual gears; and the test-pieces are cheap, readily obtainable, and standardised.

APPARATUS

The machine used has four 1 in balls. It was converted from a radial drill and could run at speeds varying from 4 to 450 r.p.m. by varying the field current of a d.c. motor, and using intermediate pulleys and gearboxes. A straight S.A.E. 10 oil was used throughout the experiment. Its viscosity was 20½ centistokes at 100° F and 3·3 centistokes at 210° F. No precautions were taken to keep the temperature of the cup constant, as measurements showed that, during running, it did not vary more than a few degrees above room temperature.

The bottom cup containing the three balls was mounted on a ball-thrust bearing which itself was placed on an electrically insulating base. The cup was restrained from rotating by a cord wound round it, attached to a spring balance which measured the friction. The fourth ball was mounted in a chuck and the load was applied by a rack and pinion device acting on the chuck spindle. The electric circuit was very simple; a rheostat was connected across a 6 volt car battery and the current was adjusted to remain at 1 A. The voltage drop across the moving and fixed balls was measured by a normal voltmeter. At one stage in the experiments a cathode-ray tube was used instead of the voltmeter, and a fast sweep was employed. The voltage was seen to be sensibly constant, with only occasional periods of zero voltage, which were taken to indicate complete short-circuiting of the oil film by small dirt particles.

To ensure that the moving ball was properly earthed, a small nylon cup was fixed to the top of the spindle and filled with mercury. A fixed rod dipping into it made certain that there was no contact voltage-drop between the rotating spindle and the voltmeter. The bottom cup was connected through a flexible cable direct to the voltmeter. It is important in this type of apparatus to keep the Ohmic resistance of the circuit as low as possible so that the discharge voltage will not be overshadowed by the normal voltage drop in the system.

RESULTS

A series of typical test results is shown in Fig. 7. The current has been varied at the different loads over a wide range to show the

Continuing Research and Development

shape of the voltage/current curve. They are very similar to the calibration curves shown in Fig. 1 of the previous article.

It can therefore be reasonably assumed, merely from the shape of the curve, that a coherent oil film exists. If the balls were separated only by a film of molecular dimensions, the discharge voltage characteristic of a finite oil-film thickness would *not* be observed, and the whole system would obey Ohm's law.

In Fig. 8 the discharge voltage, i.e., the total voltage drop measured by the voltmeter after the Ohmic voltage drop has been subtracted, is plotted against load on the top ball for several different speeds. The coefficient of friction is also plotted on the upper portion of the same graph. The two sets of measurements are clearly related. The coefficient of friction

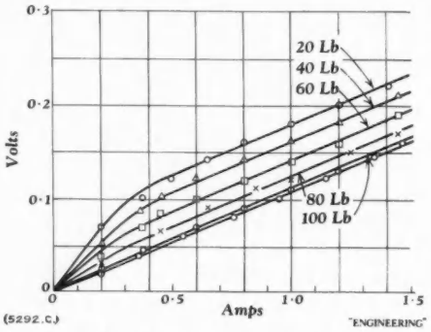


Fig. 7 Voltage/current characteristics of an oil film at 16 r.p.m.

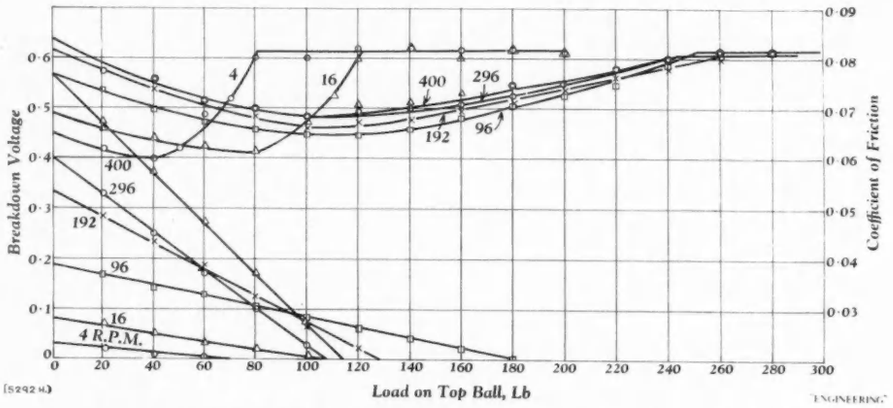


Fig. 8 Variation of breakdown voltage and coefficient of friction with load.

reaches a steady value of 0·08 at a load always slightly above the load required to bring the discharge voltage to zero. This would be expected, as the voltage will be zero when the surface roughnesses interfere, but the constant boundary value of the coefficient will only be reached at a slightly higher load, when all the oil has been squeezed out.

The surprising thing is the very large value of the oil-film thickness, as 0·225 volts corresponds to $\frac{1}{2} \times 10^{-4}$ in and a thickness of this magnitude is achieved at a speed of 192 r.p.m. and a load of 40 lb.

The load required for the discharge voltage to become zero at any given speed can be easily read off the graph. These loads are plotted in Fig. 9. It is seen at once that they are similar to the curves of scuffing loads found with discs published by Watson.[1]

The explanation is, probably, that the load-carrying capacity of the oil film increases at first with speed as predicted by normal theory. However, as the speed increases, so does the temperature, which reduces the oil viscosity. When the decrease of oil viscosity is faster than the speed increase, the curve changes direction, and the load required to give zero oil-film thickness decreases. At higher speeds (and corresponding temperatures) the change in oil viscosity is slight and the curve again starts rising.

Up to this point we have not needed to know the value of the voltage corresponding to a given oil-film thickness. The argument has depended on the shape of the voltage/current curve, and the inferences that can be drawn from the existence of a discharge voltage as described above.

In the next section we will attempt to assess quantitatively the existence of a coherent oil film using the calibration figure of $4\frac{1}{2}$ volts per 0·001 in. The fact that the voltage necessary to maintain the discharge increases with pressure will define the position of the discharge. It will occur where the surfaces are closest together when the pressure is zero, i.e. at the end of the pressure curve on the downstream side.

CALCULATION OF PRESSURES

The argument so far has led us to suggest that the balls are separated by a coherent oil film. Using the calibration obtained above, the magnitude of this oil film can be found. The apparatus allows the frictional drag to be measured, and in addition the surface speed is known and the Hertzian area of contact can be determined.

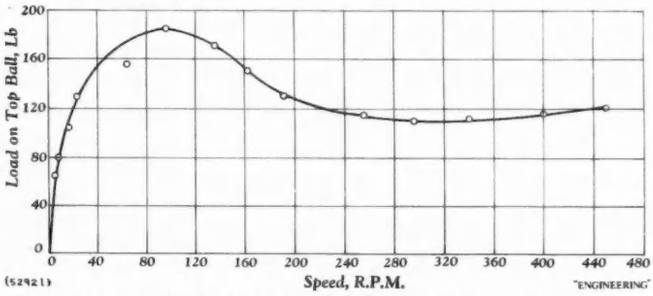


Fig. 9 Variation of load at zero oil-film thickness with speed.

The work of Vinogradova and Grubin[2] shows that the pressure distribution between lubricated discs is very nearly Hertzian and that the surfaces are nearly parallel over most of the surface. This argument, in a slightly different form from the one given by these authors, will be found in Appendix 1.

This enables us to use the simple Newtonian law for frictional drag, which is that $F = \eta \frac{U}{h} \pi r^2$, where F is the total frictional force, η the mean viscosity between surfaces, U the surface rubbing speed, h the separation, and r the radius of Hertzian contact.

All these variables are known except η, which can therefore be calculated. This is found to be many times, up to 10^6, times the normal viscosity. Now if we assume the viscosity pressure law is exponential, i.e.,

$$\eta = \eta_0 e^{\alpha p}$$

where η_0 is the atmospheric viscosity, α the pressure viscosity coefficient, and p the pressure; and further, that the pressure distribution in the Hertzian area is elliptical, then the mean viscosity η is given (see Appendix 2) by

$$\eta = \eta_0 \int_0^r 2e^{\alpha p_{max}(1-x^2/r^2)^{\frac{1}{2}}} x\,dx/r^2$$

The value of the pressure viscosity coefficient α can be obtained by the correlation given by Wooster.[3] p_{max} is the peak Hertzian pressure obtained from classical elastic theory.

This integral has been evaluated in Appendix 2 and hence the expression which enables η to be obtained is

$$\eta = \eta_0 \left[\frac{2e^{\alpha p_{max}}}{\alpha p_{max}} \left(1 - \frac{1}{\alpha p_{max}}\right) + \frac{2}{(\alpha p_{max})^2} \right] = \eta_0 A$$

The value of the quantity in the square brackets, which we will denote by A, is plotted in Fig. 10. The operative variable is the non-dimensional parameter αp_{max}.

We are now in a position to be able to compare the experimental value of η, obtained from the friction measurements and the value of the oil-film thickness, with the value of η obtained from the integral putting in the Hertzian pressure derived from normal elastic theory.

Instead of comparing actual values of viscosity, it was thought a more informative method would be to compare the value of the maximum pressure needed to produce the mean viscosity obtained from the experimental values, with the maximum pressure derived from Hertz's elastic theory. In deriving the first pressure, which we will call the "viscosity pressure," we have used the value of α obtained from Wooster's correlation, and also taken as correct the reasoning of Vinogradova and Grubin (Appendix 1) that the pressure distribution is elliptical.

These results are shown in Fig. 11. It is seen that the agreement is tolerable. The pressures calculated via the viscosity and those calculated from Hertz agree within reasonable limits. It

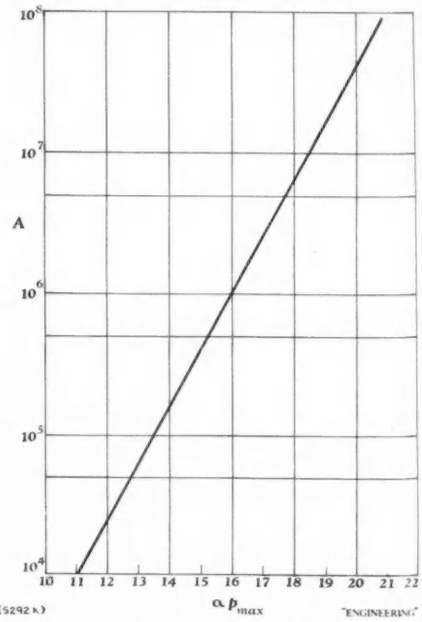


Fig. 10 Theoretical curve for evaluating the mean viscosity between surfaces.

is, however, clear that there is a definite effect of speed which should not exist. There are two possible explanations of this. The first one is that our method of taking the flash temperature into account, which was to assume that the base oil viscosity was to be calculated at room temperature plus the flash temperature, is not correct. The flash temperature is, of course, dependent on speed. The second reason, which we consider much more probable, is that the Maxwellian relaxation time of the lubricant plays an important part in the process. We have a steady-state condition where the mean viscosity is of the order 10^5 or 10^6 poises. Using a value of 10^5 dynes per sq. cm for the shear modulus, this gives a relaxation time of 1 to 10 seconds, which is very much longer than the transit time of an oil particle through the contact zone. This problem is receiving much further attention.

In conclusion, it may be said that this study gives a reasonable explanation of a number of frictional properties of the four-ball machine, and is in fact a pointer to the whole problem of thin-film lubrication. It is also interesting to see that it is possible to give this explanation using perfectly standard concepts in hydrodynamics and elasticity. No extraneous or unknown properties of the fluid are required.

We have already applied this technique to a 5 in centres back-to-back gear-testing machine. The instantaneous discharge voltage is displayed on a cathode-ray oscilloscope, and this enables the oil-film thickness down the entire length of the tooth to be measured while the machine is running under load. These results, which were obtained with oils of different viscosities, have been submitted for publication.[4]

Appendix 1. *Influence of Pressure Viscosity on the Shape of Highly Loaded Contacts*

The pressure through the *thickness* of the oil film is constant. Hence if η, the viscosity of an oil under pressure p, is given by the expression

$$\eta = \eta_0 \, e^{\alpha p}$$

then

$$\frac{dp}{dx} = \eta_0 \, e^{\alpha p} \frac{\delta^2 u}{\delta z^2}$$

where u is the velocity of an elemental particle, x is measured in the direction of motion and z in the direction of the oil-film thickness; or

$$e^{-\alpha p} \frac{dp}{dx} = \eta_0 \frac{\delta^2 u}{\delta z^2}.$$

The right-hand side is the standard form and can be integrated with respect to x to give the normal Reynolds' equation. Hence

$$6 \, U \, \eta_0 \frac{h - \bar{h}}{h^3} = e^{-\alpha p} \frac{dp}{dx} = -\frac{1}{\alpha} \frac{d}{dx} (e^{-\alpha p})$$

where h is the oil-film thickness at any point x, $\bar{h}$ the oil-film thickness when $dp/dx = 0$, and U is the rolling velocity.

Now αp is usually large in a loaded contact.

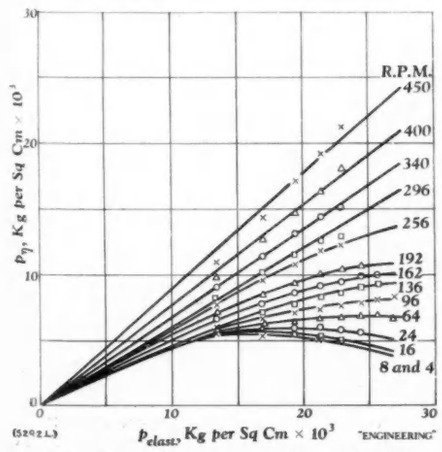


Fig. 11 Comparison of experimentally determined maximum pressure, p_{η_0} with Hertzian maximum pressure p_{elast}.

In the ball bearings we are studying here, αp_{max} varies between 10 and 20 and e^{-10} is $4{\cdot}5 \times 10^{-5}$ and e^{-20} is 2×10^{-9}.

It will be seen by a few trial values that over a very large area of contact—95-98 per cent—the value of $e^{-\alpha p}$ is very small indeed. Hence $h - \bar{h}$ must also remain nearly equal to zero.

Therefore, over the large majority of the contact area, the oil film is substantially flat and parallel. Furthermore, normal elastic theory shows that the only pressure distribution that will give a flat contact zone is an elliptical one. Hence this reasoning shows that there must be such a pressure distribution. This conclusion is required to derive the mean viscosity in Appendix II.

Appendix II

Consider a circular contact area between two spheres, separated by a parallel oil film of thickness h (Fig. 12). Let the radius of contact be r, and consider any radius x. The area of the elemental annulus is $2 \pi x dx$.

Frictional drag of annulus $d\mathrm{F} = \eta \dfrac{\mathrm{U}}{h} 2\pi x \, dx$

$\eta = \eta_0 e^{\alpha p}$, and $p = p_{max} (1 - x^2/r^2)^{\frac{1}{2}}$

where p_{max} is the peak Hertzian pressure.

Total frictional drag $\mathrm{F} = \displaystyle\int_o^r d\mathrm{F}$

$$= \int_o^r \pi \, \eta_0 \frac{\mathrm{U}}{h} 2 e^{\alpha p_{max} (1 - x^2/r^2)^{\frac{1}{2}}} \, x \, dx.$$

Writing

$q^2 = (1 - x^2/r^2)$, so that $2q \, dq = -2x \, dx/r^2$

then

$$\int_o^r x \, e^{\alpha p_{max} (1 - x^2/r^2)^{\frac{1}{2}}} \, dx = -r^2 \int_1^o q \, e^{\alpha p_{max} q} \, dq$$

which can be integrated by parts to give

$$-r^2 \left\{ \frac{e^{\alpha p_{max}}}{(\alpha p_{max})^2} - \frac{e^{\alpha p_{max}}}{\alpha p_{max}} - \frac{1}{(\alpha p_{max})^2} \right\}.$$

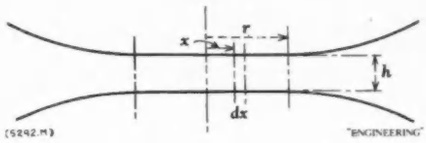


Fig. 12 Symbols used for contact zone.

Thus

$$\mathrm{F} = \pi \, \eta_0 \frac{\mathrm{U}}{h} r^2 \left[\frac{2 e^{\alpha p_{max}}}{\alpha p_{max}} \left(1 - \frac{1}{\alpha p_{max}} \right) + \frac{2}{(\alpha p_{max})^2} \right].$$

REFERENCES

Part 1

[1] Merritt, H. E. (1937), *I.Mech.E. General Discussion on Lubrication*, vol. 2, p. 95, last para.
[2] Crook, A. W. (1956), *Proc. Inst. Mech. Eng.*, vol. 171, p. 187.
[3] Crook, A. W. (1958), *Phil. Trans.*, vol. 250, p. 387.
[4] Brix, V. H. (1947), *Aircraft Engineering*, vol. 19, p. 294.
[5] Cameron, A. (1954), *Jour. Inst. Pet.*, vol. 40, p. 191.
[6] Beeck, O., Givens, J. W., and Smith, A. E. (1940), *Proc. Roy. Soc. A*, vol. 177, p. 90.
[7] Higham, J. B. (1956), Private communication.

Part 2

[1] Watson, H. J. (1957), Conference on Wear and Lubrication (*I.Mech.E.*), Paper No. 68.
[2] Vinogradova, I. E., and Grubin, A. N. (1949), Central Scientific Research Institute for Technology and Mechanical Engineering, Moscow. Book No. 30. English Translation, DSIR No. 337, p. 144.
[3] Wooster, R. C. (1951), Discussion to paper by A. E. Bingham, *Proc. I.Mech.E.*, vol. 165, p. 269.
[4] MacConochie, I. O., and Cameron, A. "The Measurement of the Oil Film Thickness in Gear Teeth". Submitted to ASME.

U.S. AUTOMATIC LETTER SORTER

A laboratory prototype machine for the automatic sorting of letter mail has been developed by the Rabinow Engineering Company, New Hampshire Avenue, Washington, D.C., under a contract arranged and supervised by the National Bureau of Standards for the United States Post Office Department. The machine is designed to sort at the rate of 36,000 letters an hour into as many categories as may be needed. Sorting can be directed by built-in electronic control, by human operators, or by a combination of these two. It is necessary for an operator to print the destination of the letter in code on the back of the envelope. The machine is of modular design and is thus adaptable to the varying needs of different post offices, in respect of both sorting complexity and space requirements.

The machine consists essentially of a large number of pockets on an endless conveyor together with electro-mechanical equipment that controls the dropping of the letter from a pocket into a specific fixed receptacle. Accompanying each pocket on the conveyor is a steel rod carrying 12 nylon wheels. Each wheel can be shifted laterally on the rod into one of two positions. There are thus 4,096 wheel positions. As the conveyor moves, each set of 12 wheels rolls over tracks designed so that when the correct receptacle is reached all the wheels drop into depressions and the letter is released.

The mechanical sorting and coding of letter mail begins at the code printer. There letters from a stack of "faced" mail are picked off a conveyor belt and automatically placed in a reading-coding position in front of an operator. He reads the addresses, abbreviates their important parts, and types the abbreviations on the back of the envelope by means of a special printer. The print coding is in a binary form requiring 6 bits for each alphanumeric character. Not more than 64 bits would be required for the entire abbreviated address.

Having printed the code on the back of the envelope, the operator then chooses, by means of push buttons, one of four possible destinations —local, outgoing, air mail, or miscellaneous—and sends the coded letter through its first sorting. The mechanism actuated by the push button opens a trap door and sets a directing vane so that the coded letter drops into the proper presort direction when it is released from the code printer.

It is expected that only a few seconds will be required to code an average letter and this operation may ultimately be the only human one remaining in the whole process. Should automatic reading machines become available, they could be incorporated into the system making it entirely automatic.

A code reader is situated immediately in front of the point where the letter is dropped into the pockets on the conveyor. The code wheels are set by an "electronic director," which receives the envelope address from the code reader. The directory, sometimes called a memory or translator, looks up the sorting destination corresponding to the coded address and sets the wheels accordingly. The entire sequence of looking up the destination of the letters and setting the wheels is accomplished in about 0·1 sec.

The electronic directory is an electro-mechanical-optical device specially designed to meet the requirements of the sorting machine. It converts, according to a pre-arranged schedule, the information in the 64-bit code of the address into the 12-bit code corresponding to the receptacle. Contained in the directory are 64 plates of stainless steel, each approximately 1 ft square. Into each plate are etched 40,000 holes of $\frac{1}{30}$ in diameter and spaced on $\frac{1}{16}$ in centres. The plates are initially covered with an opaque black ink that fills the holes completely. Some of the holes are punched out to provide the

Continuing Research and Development

directory with the address conversion data.

Each plate corresponds to a dot position in the binary address code. If the code contains the full 64 dot positions, and if, by convention, each plate moves to the right when a dot is present and remains stationary when it is absent, each address will cause the plates to move into a unique set of positions.

Behind the 12 plates, four photocells are located, each viewing an area of about 3 in by 4 in of the plate stack. The four areas do not overlap. In front of the plates is a source of light that illuminates the whole area of the plate stack. Removal of ink from certain of the holes in each plate, to permit the light to reach any desired combination of photo-tubes, creates a function table that converts a 64-bit input to a 12-bit output.

Etching the holes has ensured an accurate position for each hole, so that any set of 64 holes in the final stack will line up. The directory contains about 1·5 million bits and no trouble with mechanical alignment of the holes has been experienced so far. The plates can easily be moved in 0·1 sec, thus keeping up with the rate of the sorting conveyor. As each letter is inserted into a separate pocket on the conveyor, the code wheels of the pocket are set according to the output of the directory. A code wheel resetter returns all code wheels to their "zero" position after the letter has dropped into its receptacle.

Because the letters are carried along vertically, with their faces perpendicular to their motion, the overall speed of the conveyor can be kept low. Gravity drops are used, both for placing the letters on the conveyor and for placing them into their final receptacles. Considerable effort is spent to ensure that the facing of the letters is preserved. Thus the addresses of the letters still face the same way after sorting, and a re-facing operation is not necessary for subsequent processing.

The Bureau state that special provisions are being made to enable the conveyors to be stacked in various arrays, so that the letters can be transferred from one conveyor to another for multiple sorting. The Bureau are making studies to find systems of sorting mail which will be economical both in cost of machinery and in the effective employment of operating personnel. It is possible to sort letters by short conveyors and use several successive sortings, or to use long conveyors and fewer sortings, or combinations of long and short conveyors, to ensure that some mail is sorted only once, while other mail is sorted more often, depending upon its volume and statistical distribution. Many of the factors involved in system design are difficult to evaluate; as, for example, the repeated handling of envelopes not designed for machine use, compared with the cost of the large machinery required to handle the letters only once. Actual experiments with these machines in a post office should help to settle such problems in the next few years.

CONTRACT RESEARCH FOR CHEMICAL ENGINEERS

Open Day at Sondes Place

Mobile version of the Ricardo steam engine and boiler, designed as a cheap source of power for under-developed countries.

Some 10 years ago, a firm of consulting chemical engineers decided to set up as an organisation for carrying out sponsored research in chemistry, chemical engineering and mechanical engineering, and, as a result, the Sondes Place Research Institute (SPRI) at Dorking, Surrey, came into being in June, 1948. The Institute has prospered and expanded in scope and facilities during the succeeding years, and to celebrate the tenth anniversary of its establishment, an open day was held recently, at which some of the non-confidential work undertaken was displayed, with the agreement of the sponsoring firms concerned.

SPRI aims at providing a flexible service, capable of applying basic scientific knowledge, rather than highly-specialised "know-how," to the solution of varied practical problems—such as why bottled beer gushes (a Guinness-sponsored project), the development of pilot plant for making plastics with a high resistance to heat, chemical attack and abrasion (for Peterlite Products Limited), and the investigation of sugar as a raw material for chemicals (sponsored by the Sugar Research Foundation, New York).

Still in the laboratory-specimen stage, but showing considerable promise, is the development of vapour-diffusion processes, such as siliconising, chromising and boronising, for producing oxidation-resistant coatings on metals subject to very high temperatures. Such coatings can be produced in controlled thicknesses and applied after all the major machining operations have been completed. They have potential applications to gas-turbine blading, wear-resistant machined parts, and chemical plants where advantage can be taken of their excellent chemical resistance.

In co-operation with the National Research Development Corporation, SPRI is developing applications for the Ricardo steam engine and boiler, which was designed to provide a power source for under-developed countries, where fuel for internal-combustion engines is not easily obtainable. On view at Sondes Place was a demonstration of log-sawing powered by a Ricardo transportable unit. The boiler operates on any combustible material, such as wood, peat, or agricultural waste. The engine, which is largely of light alloy construction, produces 2½ h.p. at 1,250 r.p.m. and a steam pressure of 150 lb per sq. in.

80 PER CENT THERMAL EFFICIENCIES

Under contract to the Ministry of Power, SPRI is developing fuel cells for the direct conversion of the chemical energy of industrial fuel gases into electrical energy. Thermal efficiencies of 50 to 80 per cent can be realised with such cells, which are, in fact, primary cells wherein the overall chemical reaction is the oxidation of fuel to carbon dioxide and water. The electrodes consist of the fuel gas and an oxidant gas, which, in the case of the Institute's fuel cells, is air. SPRI is using fused lithium oxide as an eletrolyte, the operating temperature being 450 to 500° C. The open circuit voltage obtainable is about 1·2 V per cell and, at 0·75 V, the current density is approximately 60 A per sq. ft.

The small single cells, on which the Institute has so far been working, require heating to maintain the desired operating temperature, but in the 2½ kW multi-cell battery now being developed—which should be running next year—sufficient internal heat should be generated to make it self-sustaining, once the reaction has been started by an external heater coil.

Probably the first application of fuel cells will be to secure the utilisation of waste combustible gases (as, for instance, at oil refineries). They also have possibilities for small power-producing units, for some transport purposes and for the generation of low-voltage direct current for electro-chemical processes. It does not seem likely at present that fuel cells will be used for large-scale power generation.

THE NATIONAL CHEMICAL LABORATORY

The Chemical Research Laboratory, Teddington, Middlesex, has a new name. It is now called the National Chemical Laboratory. The change has been made because the previous title suggested that the laboratory existed primarily to serve the chemical industry, which already has extensive research facilities, or to carry out work over the whole field of fundamental chemical research. This is not so. The purpose of the laboratory is to undertake selected fundamental and applied chemical researches of national importance which would not otherwise be undertaken.

The Lord President has approved changes in the functions of the laboratory. It will concentrate its effort on a few objectives, covering only a limited part of the whole field of chemical research, such as the following. (1) Problems which are not appropriate to industrial research laboratories or to universities, because of the need for special facilities. Such problems include the determination of the fundamental physico-chemical properties of chemical compounds which are required, for example, by chemical engineers in the design of full-scale industrial plant. (2) Problems whose solutions are of economic value to the nation and have wide applications to many industries, for example, fundamental and applied research on corrosion of metals. (3) Problems, the solutions of which are required urgently in connection with the United Kingdom's atomic energy programme; these are mainly concerned with the extraction of elements of atomic energy interest from low grade ores.

Marketing

SELLING MANUFACTURING LICENCES

There is a belief, widespread in British industry, and in British engineering particularly, that prevailing economic winds (which began to blow as long ago as 30 to 40 years) impose upon a company a need to have products as varied as managerial and production resources will permit. There is also a tendency to look outwards, beyond our shores, for new products—whether they are needed to diversify or merely to keep up to date. To develop an invention takes time—in many cases in the engineering field, two, three or four years. One way of buying time lies in paying for ready-developed ideas in the form of manufacturing licences for new products.

One of the largest markets for new products, and one which is not generally recognised as such, is the United States. Those who specialise in "idea broking" know this only too well and have for some years now achieved more turnover in selling new products and patents to America than the reverse. The United States manufacturers' search for new products is increasingly being directed overseas, and there exists a keen and continuing wish on their part to learn of new developments, either as a basis for manufacture under licence or for import and distribution of suitable products. An Englishman resident in Chicago writes that many manufacturers have concluded such arrangements in recent years, "as a means of diversifying their activities and keeping fully abreast of technical progress in their own field." General Motors are a case in point. There is, therefore, he says, "a good possibility that efforts to market patent rights will be rewarded by direct exports in many cases, even if ultimately developing into royalty arrangements."

Opportunities doubtless exist for British firms with patents to sell. The National Research Development Corporation, with relatively few patents in its portfolio active at any given time, have concluded that a United States office is justified. A new British firm, Product Selection Limited, have recently opened offices in Detroit and Chicago, on the grounds that this is one of the richest and most highly diversified areas in the United States with the greatest prospects of expansion (through the St. Lawrence Seaway, which will bring the Great Lakes cities into world trade on a much larger scale than ever before). To approach American industry with new technical developments to sell is an excellent entrée to top management of manufacturing firms. Quite apart from the value of business which can be transcribed—and it can be very large, in dollars—there are few better ways of establishing a worthwhile link with American business.

Delegation to Canada

A first-class guide to the Canadian market has just been produced as a result of a full month's visit to that country by a small but powerful delegation sent there by the Dollar Exports Council. Their leader, Sir William Rootes, is chairman, and most of his colleagues actively serve the Council: Sir Charles Hambro is chairman of the finance committee, Sir Edward Herbert chairman of the North American Committee, Mr. Peter S. Young is their chief executive and several others are heads of organisations represented on the Council, such as the Federation of British Industries (Sir Norman Kipping), the Scottish Council (Lord Polwarth), and the Trades Union Congress (Sir Vincent Tewson).

The objects of the delegation were primarily to return the visit of the Canadian Trade Mission to the United Kingdom in November and December last year, and also to make sure British industry had every opportunity to take advantage of the highly favourable political climate now prevailing under Mr. Diefenbaker's leadership. They made personal contact with the newly established regional committees of the Dollar Sterling Trade Council, collected up-to-date information on commercial conditions in Canada, "in order to give fresh guidance to British manufacturers and exporters with regard to the prospects and opportunities in the Canadian market," and reviewed the machinery of co-ordination in the field of trade promotion between the various United Kingdom agencies operating in Canada.

The delegation's report, *Dollar Exports Council Delegation to Canada—A Report to British Industry*, is 50 pages of well-presented down-to-earth information and stimulating good sense.

Canada's National Exhibition

The forthcoming Canadian National Exhibition at Toronto from 20 August to 6 September is being well attended by British manufacturers. There has been an enthusiastic response to the Board of Trade's invitation to exhibit on the stand where the Council of Industrial Design is staging a display of consumer goods.

The "Ex," as it is known in Canada, is the largest show of its kind in North America. It has been growing since 1879 and three million people are expected to attend it this year. Both capital and consumer goods are included. On the British stand 133 manufacturers will be represented by 300 products, including building fittings and domestic equipment, office equipment, radio and record players, and sports goods and toys. The British stand, designed by Leslie Gooday (one time staff architect to Sir Hugh Casson for the Festival of Britain Exhibition in 1951), has an area of some 3,000 sq. ft, with a honeycomb of exhibits sheltering behind "a great aluminium sculptured lion."

British Gold Medal at Brussels

One British firm, James H. Randall and Son Limited, won a gold medal with their "Planstore" equipment for the outstanding exhibit in their class at the International Inventors' Exhibition in Brussels recently. Randall's had been invited to show their patented drawing storage equipment by the Institute of Patentees and Inventors, and sent their chief engineer to demonstrate the equipment.

Within three days of showing, the Belgian agency was placed with one of the largest distributors in that country, who had booked substantial orders, and they have had inquiries from other European countries, including Germany and Sweden. In their announcement the firm say that Planstore equipment "is the answer to the troublesome, costly and twofold problem of storing drawings and finding them again within a matter of seconds." With this claim it is to be hoped that they will not forget the home market, to give British engineering companies an opportunity to save the thousands of D.O. man-hours spent looking for the right drawing.

Timely Warning

For the first time since it began to appear regularly each quarter the G.E.C. *Export Guide* registers "a marked deterioration of export prospects in some of Britain's best overseas markets." These markets include the United States, Western Germany, Australia and South Africa. A number of primary producing countries are under the heading of "bad" for current prospects, including Argentina, India, the Irish Republic and New Zealand. There have been, in fact, considerable changes in trading opportunities during the second quarter of 1958. Some have improved, for example, in Denmark and Sweden, others remain good (11 countries, including Canada, Iran, Iraq (now not so good), Italy, Venezuela and the Soviet Union. We must, however, be prepared for a severe dip, unless a considerable expansion can take place in markets previously closed to British products.

The *Guide* discusses prospects for east-west trade, noting that the outlook is "moderately favourable at present" but that "a really vast uprising is unlikely." The major hopes lie in a pruning of the embargoes on exports to the USSR and China. If this were done there is every prospect that the engineering industry could more than make up the shortfall of exports in other markets which have been severely hit by the fall in commodity prices. The July *Export Guide* is a most interesting and useful document. Too much "make believe" in export prospects will not solve our problems.

India's New Export Drive

Indian industry is being threatened with creeping paralysis through the lack of foreign exchange to purchase its needs of machinery and equipment. In an attempt to counteract this, the Government have launched an intensive export drive backed by the removal of export duties and restrictions on a large number of products. Import of certain raw materials, hitherto banned, is now permitted if the goods manufactured from them are for export. Incentives to exporters may well follow the launching of this drive. Among them will probably be permission for exporters to retain a proportion of their foreign exchange earnings for the import of certain essential raw materials, hitherto banned, a more liberal grant of credit facilities at a lower rate of interest and a number of concessions in direct taxes.

These measures certainly appear to match the drastic situation which has arisen from the fall in India's exports in recent months. However favourable India's neutralism may be for commanding loans from both sides (and so far this has not been signally successful) the ultimate success of her industrialisation drive—and therefore of her efforts to raise living standards—lies almost entirely in improving her exports.

Useful and Down-to-Earth

The contribution of the Birmingham Exchange and Engineering Centre to British engineering's attempts to make its mark in overseas exhibitions has been most important during the current and past years. We have from time to time commented upon specific services rendered by the Centre to their members and to the industry generally. At Poznan (8 to 22 June) their representative handled all inquiries received on the Government stand in the British pavilion. Their report of this fair (*News Letter*, No. 41, July 1958) is one of the most encouraging received about British efforts in Eastern countries.

Great Britain occupied the third largest national area after Western Germany and the United States, followed by Eastern Germany, the Soviet Union, France, Czechoslovakia, Austria and China. The fair has tended to increase in size and importance since the war and the number of British exhibitors has increased from 20 in 1950 to 31 this year. A few of the British stands were organised sales groups representing many additional firms. The British pavilion therefore displayed a fair selection of products, including textile machinery, mechanical handling equipment, agricultural machinery, trucks, diesel engines, motor cars, electronic and electrical equipment and many industrial items such as welding machines, nuts, bolts, rock drilling equipment, etc. *News Letter* gives some facts on Poland, and information on the inquiries received. There is in this a down-to-earth practical, quality which makes the Centre most useful to the industry they serve.

On the Shelf

By Frank H. Smith

Cumulative indexes are the thing. They are talked about in all the best bars and hostelries and are generally regarded as tops. *Scientific American* has fallen for them and there is one on the way for that journal, covering the years 1948-57. At a pre-publication price of 6·95 dols (as against 9 dols) the index should be most useful, particularly if you happen to have taken *Scientific American* for the past ten years. It is reckoned that there are 60,000 references in the index, "a virtual encyclopaedia of contemporary science."

One of the most intriguing and useful books to come my way recently is *Who Owns Whom*, a directory of the subsidiaries and associates of public companies in industry and commerce. It lists over 12,000 companies and answers the oft-recurring question—"Aren't they a subsidiary of another company?" The ideal present for the librarian or information officer who has longed for an unfailing trick to impress the managing director with his omniscience. The publishers say they will produce revised editions if there is sufficient demand; I'll be surprised if they don't find they have to publish the book at regular intervals. It is £4 4*s*. from O. W. Roskill and Company (Reports) Limited, 14 Great College Street, London, S.W.1.

The Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2, is inviting entries for the 12th Congress of the International Scientific Film Association to be held in Moscow from 10-20 September this year. A ring to TEMple Bar 4694 will bring further particulars.

Micro Methods Limited, East Ardsley, Wakefield, Yorks., have sent me their catalogue of published material available on film, fiche and card. It is in two parts—the first, Micro Publications available from U.K. Sources, and Part II, Microcard Publications available from Overseas Sources. The parts are divided into subject headings.

Elsevier are producing "an international journal on fundamentals of friction, lubrication, wear and their control in industry." It is called, simply, *Wear*, and, lest there be confusion with jackets and trousers, in smaller type beneath, Usure, Verschleiss, thus emphasising its internationality.

The Journal of Commerce, 80 Varick Street, New York, 13, U.S.A., a newspaper-type economic periodical, has produced a supplement, "Profitable Foreign New Products," 1958 edition. This is a 15-page pamphlet with about nine or ten products described on each page. The products are things like coffee grinders, a bottle cooler, a welding press, a ball-point barometer, and so on. The word "foreign" appears to mean exclusively German and Japanese products.

Pergamon, 4/5 Fitzroy Square, London, W.1, are advertising translations of Russian journals *Radio Engineering* (£10 14*s*. 0*d*. for 12 issues), *Telecommunications* (£10 14*s*. 0*d*. for 12 issues), *Radio Engineering and Electronics* (£16 for 12), and *Electric Technology* (£6 for 4), or the lot for £20.

Can I describe an article as essential without being misunderstood? That is, I feel, the word for "Machines and Documentation," by H. Coblans of the European Organisation for Nuclear Research, Geneva, in *Discovery* for July. It deals with punched-card selection and microreproduction, and their use in overcoming our surfeit of literature. He quotes the flap that arose in the United States when Sputnik I was elevated. It was known that our red friends had published the frequencies for Sputnik's emissions, it was known that the appropriate journal had been received in Library of Congress. But our starred and striped friends had not got around to translating the vital article. The picture that is conjured up by such a situation is wonderful.

Book Reviews

PHYSICAL SCIENCE IN SUMMARY

Dictionary of Physics. Edited by H. J. GRAY. *Longmans, Green and Company, 6 and 7 Clifford Street, London, W.1.* (84*s*.)

Character and presentation are almost as important in a reference book as content, and it is legitimate in a review of such a volume to refer in some detail to its virtues and shortcomings. *Dictionary of Physics*, containing 541 double column pages and 450 figures, provides, in a single volume of manageable proportions, a comprehensive source of reference that will have a wide appeal. It is a work of British origin and the list of contributors appearing in the preface includes many familiar names, and guarantees the authority of their contributions.

The entries, alphabetically arranged with numerous cross references, vary in length from a few lines to several pages. The briefer entries are mainly devoted to definitions of terms and statements of laws. The longer ones consist of more general articles giving a connected account of particular topics, such as the diffraction of light. Additional information is supplied in the form of copious references either to recognised standard texts (though not always to the current edition) or to original papers. Certain of these texts are cited so often that space might have been saved by listing them separately and referring to them by number. Examples are the *Dictionary of Applied Physics* and Whetham's *Theory of Solution*, incorrectly stated on pages 102, 108, 151 and 172 as belonging to the Cambridge National Science Series but correctly given as one of the Cambridge Natural Science Series on page 238 and elsewhere. In a few cases names of publishers require correction, for instance, Arnold instead of Humphrey Milford for Aston's *Mass Spectra and Isotopes*.

Welcome features are the articles on the elements and the biographical notes. The former include information on their physical properties, discovery, crystalline form, physical and chemical characteristics, stable and radioactive isotopes. The latter give the dates of leading physicists and summarise their chief contributions. All branches of physics are dealt with up to about 1955 and reasonable coverage is provided for the border line subjects of mathematics, astronomy and electro-technology.

Except for a few reservations, such as metaphysics and motor-coach, nearly everything that has been included clearly merits inclusion. Some omissions are inevitable, perhaps even intentional. Some subjects, such as electrical measurements, are not pursued in any great detail but acoustics is treated remarkably fully and specially well.

Misprints are not unduly numerous. Among those noted were Hartru for Hartree (page 68), Runnering for Running (page 221) and Le Chatelin for Le Chatelier (page 293). The synonym for hydrometer (page 249) is areometer not anometer and the instrument illustrated in Fig. 398 is a spherometer and not a planimeter. The discovery of the interference of light is attributed to Thomas Young in 1801, though Newton's rings are mentioned as an interference phenomenon later in the course of the same article. Iridium was discovered by Tennant in 1803 not in 1930. The maximum value of A does not occur at the value stated on page 201. These minor defects do not, however, seriously detract from the high standard of usefulness of the work as a whole. It is certain to be consulted widely and to good purpose by physicists and engineers at all stages of their studies.

NEW BOOKS

Nonlinear Control Systems. By ROBERT LIEN COSGRIFF. *McGraw-Hill Book Company, Incorporated, 330 West 42nd Street, New York 36, N.Y., U.S.A.* (8·75 dol); and *McGraw-Hill Publishing Company Limited, 95 Farringdon Street, London, E.C.4.* (70*s*.)

The author believes this book to be the first that deals in detail with the analysis and design of nonlinear control systems; it is intended both for the practising control engineer and the student. It includes a concise treatment of linear theory as a background; examples worked out to illustrate each of the important developments; problems similar to those commonly encountered in practice, and answers; and use of the concepts and terminology of automatic-control theory rather than those of classical mechanics. The ground covered embraces small signal theory, techniques for the analysis of non-linear systems, frequency response of non-linear systems, linear equations with periodic coefficients, application of statistical methods, and logic circuits as control elements. An appendix provides a table of integrals.

British Plastics Yearbook 1958. 28th Edition. *Published for "British Plastics" by Iliffe and Sons, Limited, Dorset House, Stamford Street, London, S.E.1.* (42*s*.)

A review of recent patents, new companies registered in 1957, and specifications, classified lists of raw materials, manufactured products and plant and equipment are among the subjects set out in this very comprehensive and well set-out handbook. There are also glossaries of trade names and technical terms, and a directory of firms, organisations and consultants in the United Kingdom and overseas, together with a "Who's Who" in the plastics industry followed by general technical data for the plastics industry. There is a very full general index.

Technical Reports of the Electrical Research Association, *Thorncroft Manor, Dorking Road, Leatherhead, Surrey.*

"The Inflammability of Silicone, Melamine and Phenolic Resin Bonded Sheets," by W. J. Renwick, A/T139 (7*s*. 6*d*.); "The Effect of Filler Deficiency on the Performance of Cartridge Fuses, with an Appendix on a Suggested Filler-Deficiency Test," by H. W. Baxter and A. R. Galanides, G/T308 (10*s*. 6*d*.); "The Distribution of the Electric Field between Parallel-Plate Electrodes," by C. V. Jones, L/T334 (21*s*.); "The Distribution of Cathode Vapour in the Vicinity of an Arc Cathode Spot," by A. E. Robson, L/T340 (7*s*. 6*d*.); "An Analysis of the Problems Relating to the Protection of Meter Jewels and Pivots from Damage Due to Shock," by G. F. Shotter and G. F. Tagg, T/T53 (12*s*. 6*d*.); "Heat Pump Sources, Heat Transfer from Soil to Buried Pipes," by M. V. Griffith, Y/T18 (12*s*. 6*d*.).

Castilla's Spanish and English Technical Dictionary. Vol. I: English-Spanish. Vol. II: Spanish-English. *Routledge and Kegan Paul Limited, Broadway House, Carter Lane, London, E.C.4.* (294*s*.)

Only the field of engineering technology is dealt with in this dictionary, and the physical, chemical and biological sciences are excluded. Important everyday words, however, are included to avoid the necessity for the translator to have to refer to a general dictionary. Leading clerical and legal terms are also included, since the compilers expect that the dictionary will be used in Anglo-Spanish commerce. It is arranged in alphabetical order by words and does not contain cross references. When dealing with words that are untranslatable, a brief explanation is given.

Guide to the Coalfields 1958. Edited by R. H. WALKERDINE and E. G. CORBIN. *The Colliery Guardian Company Limited, 30 and 31 Furnival Street, Holborn, London, E.C.4.* (20*s*.)

The main portion of the *Guide* is concerned with the collieries of the National Coal Board: their organisation, location, products, etc. It is most comprehensively mapped. In addition, information on the principal departments of the Ministry of Power and a list of H.M. Inspectors of Mines are given. Particulars of the coal industry social-welfare organisation, learned societies and institutions, trade unions, the Federation of Small Mines of Great Britain, the Coal Utilisation Council and other bodies.

Design

CALCULATING STRESSES IN SHIPS' MASTS

Designs of High Strength-Weight Ratio

By F. J. Halligey, A.M.I.E.E., A.M.(S.A.)I.MECH.E.

The popularity of sailing in small craft has increased enormously in many parts of the world in recent years, and the interest thus aroused in the efficient design of hulls, masts and other equipment, has contributed to their enhanced performance. One of the principal aims of ship design is to improve the strength-weight ratio of all parts of the equipment, and the purpose of this article is to examine methods of achieving this purpose in the case of the masts of dinghies and small cruisers.

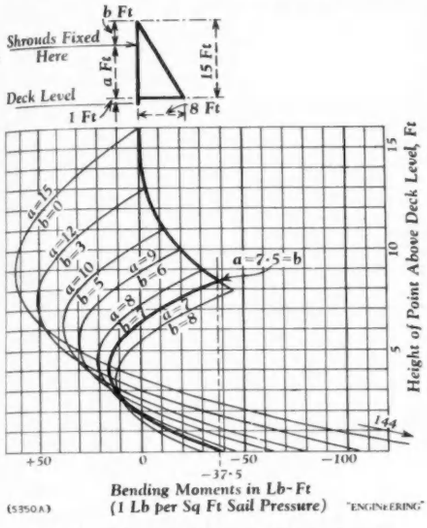


Fig 1 Mast Built-in at Deck Level.

Stresses on Masts.—If a mast is treated as a vertical beam, on which a triangular sail is mounted, it is possible to compute the bending moments along the member for various methods of support. There are commonly two such methods in general use. In the first, the weight of the mast is supported on a step fixed to the keel, and it rises up through a hole in the deck where it is solidly built in; shrouds are attached at a point in the mast between the deck and the top to give lateral (athwartships) support. Fore-and-aft support is given by a forestay running from near the top of the mast to the bow, and by a backstay which runs from the top of the mast to the stern of the vessel. This type of support results in a mast which forms a propped cantilever. In the second method of support, the base of the mast is not attached to the vessel but is merely pivoted on the deck; all the support being given by rigging arranged as in the first method. Such a mast forms a simply-supported beam.

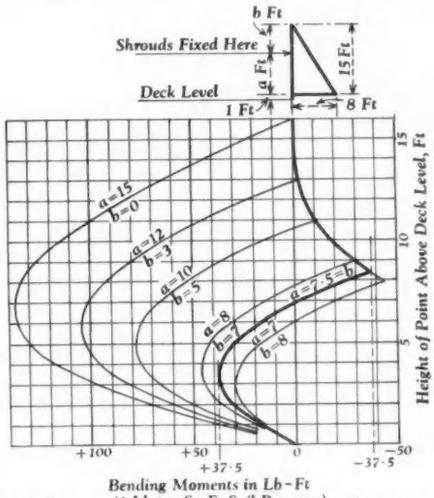


Fig. 2 Mast Stepped on Deck.

Bending moments arising in masts supported as described will alter, in the lateral direction, according to the point in the mast where the shrouds are attached, and it was the first object of the present investigation to determine what this alteration would be. Bending moments were accordingly computed for the two alternative methods of support, taking into consideration only the horizontal components of the support point reactions. The resulting series of bending moment diagrams are reproduced as Figs. 1 and 2, for masts built in at deck level, and pivoted on deck, respectively. For the purposes of these calculations, it was necessary to assume numerical dimensions for the masts and sails and the loading on the latter, but the figures obtained can be converted to suit other mast heights.

Two facts stand out clearly from the study of the bending moment diagrams. First, the curves showing the least maximum bending moments for any position in the mast are those where the point of attachment of the shrouds is located half-way up the height of the sail. Secondly, the numerical values of the least maximum bending moments in those curves are exactly the same whether the masts are equivalent to simply-supported beams or to propped cantilevers, although occurring at different heights in the two cases.

Having secured these bending moment diagrams, it is necessary to ascertain the probable loading on the sails if suitable masts are to be designed. Sail loading is dependent only on the velocity of the wind relative to the ship, and can be calculated fairly accurately from the relationship $P = \frac{V^2}{400}$, where P is the pressure in lb per sq. ft on the sail, and V is the wind speed relative to the ship in knots. It can be shown that a dinghy will overturn if the lateral wind pressure on its sails exceeds about 1·5 lb per sq. ft, so that it is not necessary to design the lateral strength of a dinghy mast for greater pressures than that. Fore-and-aft strength needs to be based on somewhat greater sail pressure, but it can be assumed that a dinghy will seldom sail with winds astern exceeding about 30 knots, corresponding to a sail pressure of 2·25 lb per sq. ft. Larger vessels will require greater allowances to be made for sail pressure.

Design of Box-Beam Masts.—In the past, masts for small vessels have generally taken the form of hollow spars tapering uniformly from the bottom to the top, and having elliptical sections with the major axes fore-and-aft. Such masts are necessarily stron-

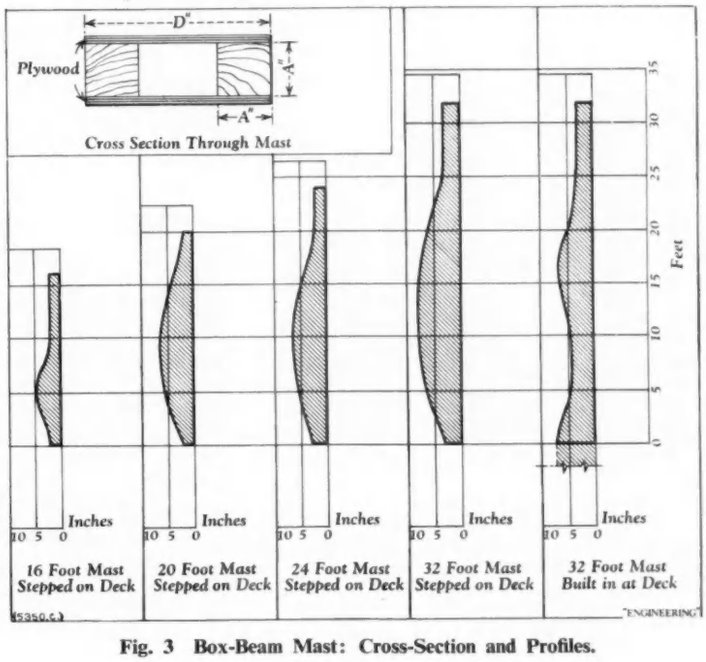


Fig. 3 Box-Beam Mast: Cross-Section and Profiles.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Flow Measurement. GEORGE KENT LTD., Luton. Dall orifice—essentially a truncated Dall tube—for measuring the flow of water, compressed air, low-pressure air, relatively clean non-corrosive gases, low-pressure steam. Gives pressure loss less than single-plate orifice but greater than Dall tube, but more compact than latter. Illustrated technical specification leaflet.

Street Lighting. HOLOPHANE LTD., Elverton Street, London, S.W.1. Acorn bowl refractor for tungsten filament and mercury fluorescent high-wattage lamps. Post-top refractors for group B roads for use with tungsten filament, sodium, mercury discharge and mercury fluorescent lamps. Two illustrated specification leaflets.

Grey-Iron Castings. R. J. HUNT & SON LTD., Lifford Foundry, King's Norton, Birmingham, 30. The production of grey-iron castings from the pattern-making stage to the final testing is briefly described in a brochure to indicate the scope and facilities offered by the firm.

Nylon Tubing. TECALEMIT LTD., Plymouth, Devon. Tough, light-weight, stable flexible or semi-rigid nylon tubing, in sizes ranging from $\frac{1}{8}$ in to $\frac{3}{8}$ in, for lubrication, hydraulic, chemical, air, fuel, and oil lines. Illustrated folder.

Bitumen Roofing Materials. THE RUBEROID CO. LTD., Commonwealth House, 1-19 New Oxford Street, London, W.C.1. Design considerations, materials and specifications relating to built-up bitumen or Ruberoid roofings. Illustrated catalogue.

Vertical Air-Circulation Furnaces. METALECTRIC FURNACES LTD., Cornwall Road, Smethwick, 40, Staffordshire. Vertical air-circulation furnaces for precision tempering and other heat treatments. Bulletin No. M.2B.

Chain Saw. J. CLUBLEY ARMSTRONG DANARM LTD., Alford House, Wilton Road, London, S.W.1. Direct drive portable chain saw powered by Villiers engine. Illustrated leaflet.

Continuing **Design**

PRODUCING COLD AIR

Simplicity of the Vortex Tube Method

By Lt. Cmdr. E. H. Otten A.M.I.MECH.E.

For many purposes it is desirable to have a supply of cold air at approximately atmospheric pressure as, for instance, in testing internal combustion engines, and the use of the Hilsch vortex tube makes this possible in a simple manner. The only requirement is a supply of air at about 5 or 6 atmospheres pressure. Temperature drops of up to 40° C can readily be obtained, and both temperature and flow can be regulated. This article records the results of an actual installation and indicates design parameters.

The Ranque-Hilsch vortex tube was first described by Ranque in 1933[1] and subsequently by Hilsch[2] and Elser and Hoch.[3] It consists of a cylindrical tube into which compressed gas enters through tangential nozzles which are located near one end of the tube, as shown in Fig. 1. This end of the tube is partly closed by a diaphragm which allows escape of gas only from the central region, and if the other end of the tube is suitably throttled, the gas escaping through the diaphragm will be at a lower temperature than the inlet, while that escaping through the throttle will be at a higher temperature.

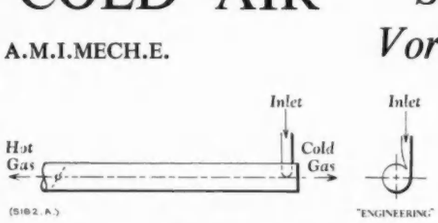


Fig. 1 Diagrammatic arrangement of a vortex tube.

The simplicity of the vortex tube makes it attractive as a means of supplying a cool gas stream at substantially atmospheric pressure provided the gas feed is available at a pressure of a few atmospheres, and temperature drops of up to 40° C (72° F) are obtainable with a compressed air supply at 90 lb per sq. in at an inlet temperature of about 30° C. With these facts in mind, the design and test of a vortex tube was undertaken for supplying cooled inlet air to a single-cylinder diesel engine for research purposes, the target being a flow of 40 cu. ft of air per minute at temperatures down to −20° C.

This apparatus may be of assistance to I.C. engine manufacturers for cold starting and cold running tests without the use of a cold room, and this is the main reason for publishing the results of this work.

VORTEX TUBE CHARACTERISTICS

During the last eight years vortex tubes have been developed for process work at the Koninklijke Shell-Laboratorium, Amsterdam, and their results were used at the Thornton Research Centre of Shell Research Limited for the purposes of the present design. A mathematical analysis of the cooling effect[4] has been given by Van Deemter of this laboratory.

Fig. 2 shows the performance curves and leading dimensions of a 28 kilogram per hour vortex tube developed at Amsterdam which was used as the basis for the design. The curves show the temperature drop of the cold flow on a base of cold fraction (μ). The cold fraction is the fraction of the total inlet flow which is allowed to escape through the diaphragm. The flow through the throttle—the hot fraction—is then $(1 - \mu)$. The curves show that an appreciably better cooling effect is obtained with a 3·6° tapered tube than with a parallel tube and that a cooled tube (i.e., water jacketed) has a greater cooling effect if the cold fraction exceeds about 0·4. The 3·6° taper is the optimum value; smaller or greater tapers show less cooling effect. At cold fractions of 0 or 1, there is no cooling of the air stream with uncooled tubes, and the lowest temperature is obtained at $\mu = 0{\cdot}3$. A cooled tube, on the other hand, still has an appreciable cooling effect at $\mu = 1{\cdot}0$, i.e., when all the inlet air escapes through the diaphragm.

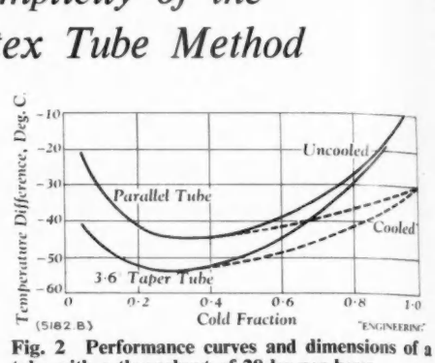


Fig. 2 Performance curves and dimensions of a tube with a throughput of 28 kg per hour.

Tube diameter 10 mm. Diaphragm diameter, 6 mm. Inlet nozzle, 5·76 sq. mm. Length of tube, 160 to 200 mm. Inlet conditions, 6 atm. at 15° C. Outlet pressure, 1 atm. Cooling water temp., 15° C. Air throughput, 28 kg. per hr

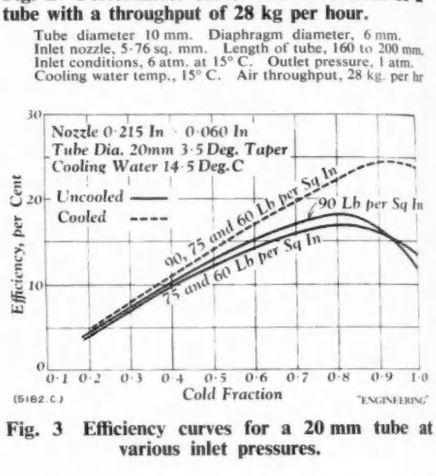


Fig. 3 Efficiency curves for a 20 mm tube at various inlet pressures.

This design represents the optimum for the highest efficiency of cooling. The efficiency can be defined as the ratio of the temperature drop in the cold stream to the total available isentropic temperature drop taking into account the mass flow, i.e.,

$$\eta = \frac{\mu \Delta T}{T_0 \left[1 - \left(\frac{P_0}{P_i}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

where: μ is the cold fraction, ΔT the temperature drop of the cold gas stream, T_0 is the inlet temperature (absolute), P_i the inlet pressure (absolute), P_0 is the outlet pressure (absolute), and γ the ratio of the specific heats measured at constant pressure and constant volume. For air $\gamma = 1{\cdot}41$.

The present design of vortex tube is based on the maximum efficiency, i.e., the maximum refrigerating effect, and not the greatest temperature drop. Greater temperature drops at small values of cold fraction flow can be achieved with smaller diaphragms. Under these circumstances the efficiency will be low.

A typical efficiency curve for an uncooled tube is shown in Fig. 3. The maximum efficiency (about 20 per cent) occurs at a cold fraction of about 0·8. Similar curves can be drawn for cooled tubes which in general show the highest efficiency near $\mu = 1{\cdot}0$ but the expression for

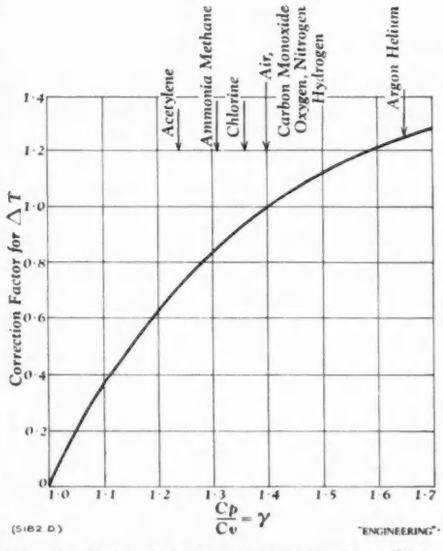


Fig. 4 Ratio of cold fraction temperature drops for different values of $\gamma \left(= \frac{C_p}{C_v}\right)$.

Continuing **Calculating Stresses**

gest at the bottom; whereas, for the best strength-weight ratio, bending moment diagrams show that the strongest section should generally be elsewhere. A mast with resisting moments accurately matched to the stresses at every point in its length can be constructed by using the box-beam section shown in Fig. 3, and consisting of two square stringers of suitable timber glued between two sheets of plywood. By varying the width of plywood from point to point it is possible to achieve a given resisting moment wherever required. Fig. 3 also shows typical mast profiles (drawn with an exaggerated fore-and-aft scale to emphasise the variations) calculated for a number of different lengths of mast. The profiles do not follow the bending moment curves exactly because the stresses in each mast must be investigated both for lateral and for fore-and-aft loading, and the stress distribution is not the same for these modes of loading because the fore-and-aft rigging can only be attached to the mast near the top (so that movement of the sail is not obstructed), whereas the lateral rigging can be attached at the most favourable point. The resulting masts have a constant width (athwartships) throughout their height, and the variation in profile is in the fore-and-aft direction. The fore-and-aft dimensions "D" have been computed twice for each profiling position to evaluate correct resisting moments in the two perpendicular directions, the greater of these two being chosen at each point.

No allowances have been made for additional stresses which might arise in the masts due to the vertical components of the tensions in the rigging, which would necessitate the estimation of columnar action, because it has been ascertained that such additional stresses would not amount to more than an extra 30 per cent; at the same time, since the sail is triangular, approximately 30 per cent of the loading will be borne, not by the mast, but by the sheet. Consequently, all stresses have already been over-estimated by approximately the amount required to cover the behaviour of the masts as columns.

Photocopies of the full paper on which this digest is based may be obtained from Mr. F. J. Halligey, Taaibos Power Station, P.O. Coalbrook, O.F.S., South Africa, or from the Publisher, ENGINEERING, 36 *Bedford Street, Strand, London, W.C.2, in each case price* 25*s.* (4 *dols to U.S. and Canada), post free. Remittances should accompany the order.*

efficiency as such is not valid for them as an efficiency of over 100 per cent is possible if the temperature of the cooling medium is low enough.

The usable operating pressure ratio for these vortex tubes is between 4 : 1 and 6 : 1 and there is little advantage in exceeding this figure. If higher pressures are available and more cooling is required, two or more vortex tubes in series may be used.

DESIGN METHOD

The design method adopted was to scale the dimensions, areas and flows of the 28 kg per hour vortex tube to the new requirements. The conditions assumed were: inlet air temperature, 20° C; inlet air pressure, 75 lb per sq. in = 6 atm. approximately; cold flow required, 40 cu. ft per min of air at −20° C; the temperature drop from inlet to cold outlet is 40° C.

From Fig. 2 this can be obtained with a cooled conical vortex tube at a cold fraction μ of 0·83.

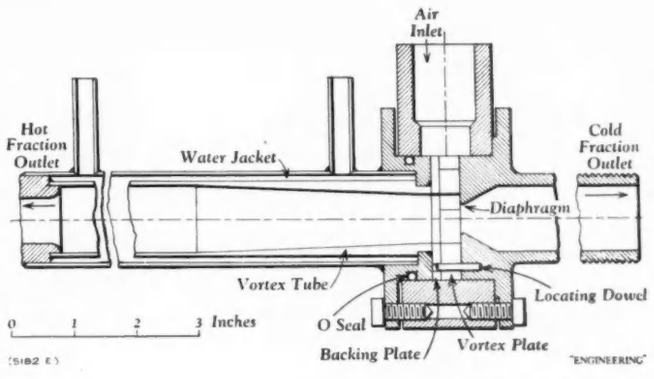


Fig. 5 (above) Longitudinal section of a 20 mm tube.

Fig. 6 (right) Component parts of the 20 mm tube.

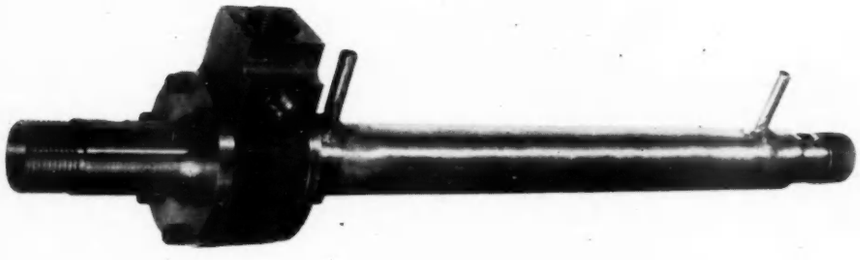


Fig. 7 (below) The assembled 20 mm tube.

Hence, total flow is $\frac{40}{0{\cdot}83}$ cu. ft per min at 20° C = 114 kg per hour.

The scale ratio is then $\frac{114}{28} = 4{\cdot}06$, say 4·0.

Rounding off this figure is justifiable if the inlet pressure may be varied over a small range to adjust the output flow to the rate required. For calculating the leading dimensions of the vortex tube, the areas and flows are multiplied by the scale ratio 4 and the lengths by the square root of the scale ratio (= 2) and we have:

Throughput 28 kg per hour × 4 = 112 kg per hour;

Tube diameter, 10 mm × 2 = 20 mm;

Inlet nozzle area, 5·76 sq. mm × 4 = 23 sq. mm;

Diaphragm diameter, 6 mm × 2 = 12 mm;

Inlet pressure, 6 atmospheres;

Tube length, 180 mm × 2 = 360 mm;

Cone angle of tube, 3·6°.

This scaling procedure also applies fairly closely to a much larger vortex tube which had been developed for process work. The throughput was 1,800 kg per hour and the scale factor approximately 64; the following table gives a comparison between the scaled-up figures and the actual design.

EFFECT OF γ

The refrigerating effect of the vortex tube depends on the ratio of the specific heats at constant pressure and constant volume. The cooling effect rises with γ. It is zero when $\gamma = 1$ and greatest for argon, helium, etc., where $\gamma = 1{\cdot}65^{2,4}$. If gases with γ different from air are to be used, a correction factor from Fig. 4 should be applied to the temperature drops on Fig. 2. If γ varies with pressure or if the Joule Kelvin effect is important, appropriate gas tables should be used.

The cooling effect can be taken as proportional to the absolute inlet temperature.

—	Basic design	Scaled up	Actual design
Throughput	28 kg per hr	× 64 = 1,790 kg per hr	1,800 kg per hr
Tube diameter	10 mm	× √64 = 80 mm	76 mm
Inlet nozzle area	5·76 sq. mm.	× 64 = 368 sq. mm	300 sq. mm
Length	180 mm	× √64 = 1·4 m	1·9 m.

CONSTRUCTION

Figs. 5, 6 and 7 show the construction of the completed vortex tube. For simplicity only one tangential nozzle to the vortex was used. It was realised that this feature would destroy to some extent the symmetry of the rotating flow, and the body was therefore made large enough to accommodate an annular passage around the nozzle plate so that several nozzles could subsequently be used.

The materials employed were: body and outlet branch—mild steel; Vortex tube—brass; water jacket—copper; Vortex plate and backing plate —18/8 stainless steel.

TEST RESULTS

Figs. 8 and 9 show the performance curves actually obtained from this design with both cooled and uncooled vortex tubes. Because of limitations in the available air supply to the test rig, the nozzle had to be somewhat reduced in size. Originally 8 mm by 3 mm (0·315 in by 0·118 in) it was reduced to 0·215 in by 0·060 in.

These modifications allowed operation up to 90 lb per sq. in gauge (approx. 7 atmospheres). The curves follow in general those on which the design was based but with some differences: (*a*) the maximum temperature drops are rather

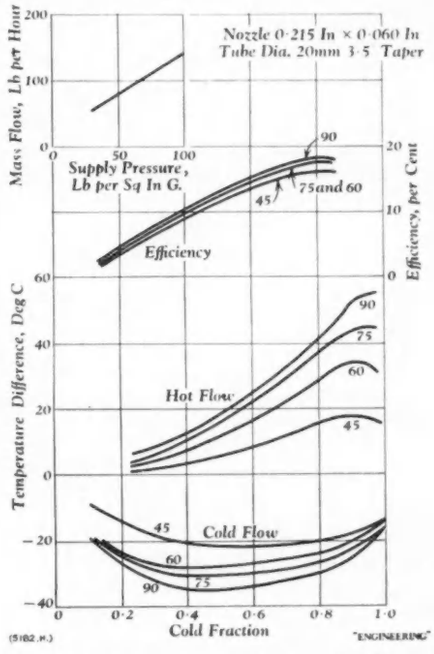


Fig. 8 Performance curves of an uncooled 20 mm tube at various supply pressures.

Continuing **Design**

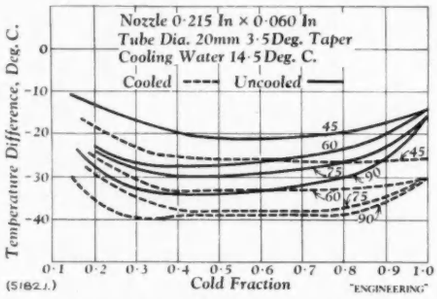


Fig. 9 Cold fraction temperature drops for the 20 mm tube at various supply pressures.

less than expected probably because of the small nozzle area for the size of the tube and because of the undried inlet air which reduced the performance; (*b*) a temperature drop of about 15° C was observed with the uncooled tube at a cold fraction of 1·0 and is probably due to heat losses on the surface of the vortex tube itself which was not insulated; (*c*) the cooled tube had a better performance than the uncooled tube over the entire range of cold fraction and not only over $\mu = 0{\cdot}5$ to 1·0 as was expected. This is probably because the cooling water was about 15° C cooler than the inlet air.

APPLICATION

The cooled vortex tube appears to satisfy the engine requirements but at a pressure of 90 lb per sq. in gauge instead of 75 lb per sq. in. In the engine installation the cold outlet branch of a vortex tube was connected via a capacity chamber to the engine air inlet. The capacity chamber must be big enough to accommodate the pulsating air requirements for a single-cylinder engine and in this instance was 30 cu. ft capacity. A pressure relief valve set to a low pressure (about 5 lb per sq. in) was fitted to the chamber because incorrect operation of the vortex tube could impose the full inlet air pressure on the chamber and engine inlet manifold.

Control of the output flow at constant temperature is readily achieved by varying the hot fraction by means of the throttle on the hot end of the vortex tube, as the performance curves are almost flat over the greater part of the range. Control of temperature at constant volumetric flow is more difficult but can be achieved by: (*a*) varying together the cooling water flow and the hot fraction; (*b*) varying together the air inlet temperature and the hot fraction; (*c*) varying together the inlet pressure and the hot fraction; (*d*) allowing air at ambient temperature to mix with the cold stream, thereby raising its temperature.

Method (*a*) will vary the cold fraction temperature between the limits of cooled and uncooled tubes; this difference is rather small except when μ is greater than 0·8. Method (*b*) is practicable but slow in operation, and the methods (*c*) and (*d*) are both practicable and have been used. However it was soon found most convenient to adopt a variant of (*d*). At the lowest temperatures the vortex tube conditions were adjusted to supply a slight excess of cold air, the surplus being allowed to escape through an open port on the capacity chamber. Higher temperatures were then obtained by reducing the nozzle supply pressure which reduced the cold flow and raised its temperature. The balance of the engine air requirements was sucked in through the open port in the chamber where it mixed with the cold flow, further raising its temperature. It was found that the engine inlet temperature could readily be controlled in this way from − 10° C to room temperature, the maximum air pressure used being 75 lb per sq. in and the air inlet temperature to the vortex tube being 20° C. This temperature drop of 30° C is about 5° C less than that produced by the vortex tube itself because of heat gains in the capacity chamber and pipework.

ACKNOWLEDGEMENT

The author wishes to thank the Directors of "Shell" Research Limited for permission to publish this article.

REFERENCES

[1] G. J. Ranque, *J. de Phys. et Rad.*, **4**, 1933, 112S.
[2] R. Hilsch, *Z. Naturf*, I (1946) 208 (in German); *Rev. Sci. Inst.* **18**, (1947) 108 (English translation).
[3] K. Elser and M. Hoch, *Z. Naturf*, **6a**, (1951) 25.
[4] J. J. Van Deemter, *App. Sci. Res.*, (1953) Section A **3**, 174.

Production

Layout to Reduce Materials Handling BLACKHEART MALLEABLE IRON FOUNDRY

The layout of a new foundry recently completed by Shotton Brothers Limited, at Halesowen, near Birmingham, has been planned and designed for the flow production of blackheart malleable iron castings. Blackheart malleable castings, it may be recalled, are produced by heating white-iron castings for a period of days in a non-oxidising atmosphere. As a result of this annealing treatment, the iron carbide within the castings is decomposed with the precipitation of "rosettes" of graphite or "temper" carbon, as it is called, throughout the mass of the iron. The resultant material is malleable and readily machinable and the name blackheart arises from the fact that, when fractured, the interior has a black appearance. The other main type of malleable iron castings, namely, whiteheart, is also produced from white cast iron; castings are subsequently heated while packed in hematite iron ore and this results in the oxidation of the carbon in the surface layers and the decomposition of the interior carbide to form rounded nodules of temper carbon. On subsequent fracture the material has a light steel-grey or white appearance, giving rise to the name "whiteheart."

The new Halesowen foundry occupies about one-sixth of a ten-acre site acquired by the firm adjacent to a railway. The foundry is intended as the first of a number of similar units, each having a capacity of about 80 tons of castings a week.

A diagrammatic plan view and flow chart of the building is given in Fig. 1. The design is such as to reduce as much as possible materials handling and other non-productive operations. Special attention has also been paid to the installation of efficient dust and fume extraction equipment so as to maintain a high standard of working conditions. Local radiant heaters are provided for the comfort of static operatives and the building is well ventilated.

Narrow analytical limits have to be maintained in the raw materials employed if a desirable carbon-silicon balance, and consequently a high quality of finished product, is to be assured. The raw material consists of Cumberland hematite iron and steel scrap and the melting plant comprises three cylindrical horizontal rotary furnaces, each having a capacity of 7 tons. The furnaces can be tilted to facilitate slag clearance and charging from an upper platform. They are fired with creosote pitch which is fed to them through a metering pump at a controlled temperature from a heated outside storage tank. The outgoing flames from the furnaces are passed through recuperators which pre-heat the incoming air to the furnaces. From each melt a test bar is cast for the determination of tensile strength, yield point and elongation to ensure that these conform to the requirements of the highest grade specified in British Standard

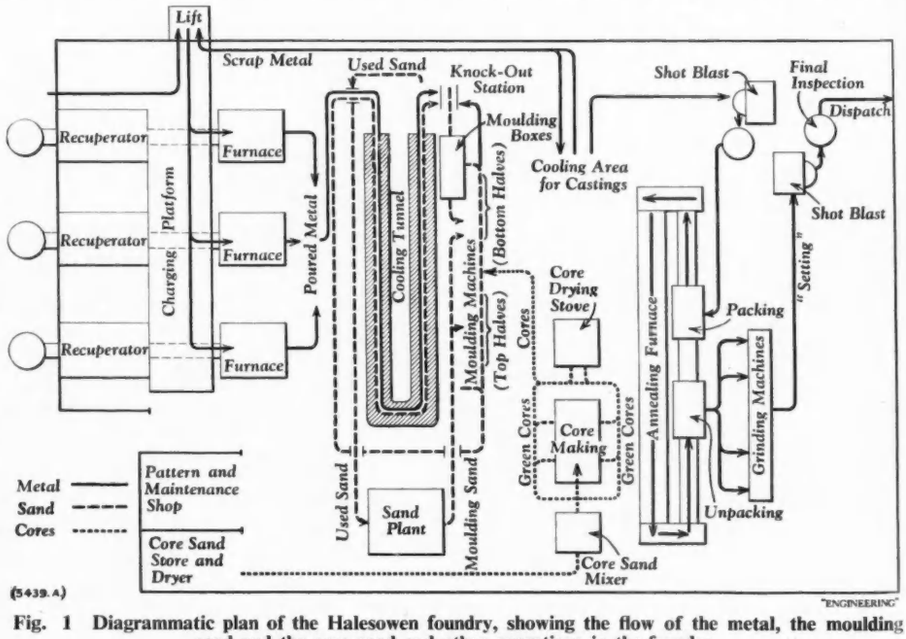


Fig. 1 Diagrammatic plan of the Halesowen foundry, showing the flow of the metal, the moulding sand and the core sand and other operations in the foundry.

310, the specification covering blackheart malleable castings.

The moulding-sand preparation plant is completely automatic; feed hoppers store the used sand returned from the knock-out station and also new sand, and bonding and other materials. Pre-set electrically-operated timing devices control the volume of each ingredient fed on to a supply belt and thence into a skip discharging into a reversible chute which feeds one or other of two batch sand-blending mills. After controlled water additions are made, milling proceeds for a pre-determined time interval. The discharge door then opens automatically, delivering the sand into a skip hoist which carries it to a distributing hopper. The distribution of the sand by conveyor belt feeding the hoppers situated over each of the ten moulding machines of the foundry, is the only operation requiring manual control.

Core oils are normally purchased ready mixed, and, after drying, the core sand is fed through a pneumatic duct to twin totally-enclosed hoppers. Underneath these are measuring hoppers and the sand is discharged into a mixing machine and is finally fed to the core-blowing machines. The green cores are dried in a thermostatically-controlled oil-fired stove, after which they are placed on portable stillages until required.

The ten moulding machines are of the jolt-squeeze roll-over type and incorporate the automatic control of the requisite number of jolts. It is intended that, when the foundry is in full production four machines will be making the copes or upper halves of the moulds and four the drags or lower halves of the moulds, leaving two machines available for pattern changing and sampling procedures. The lower half moulds are placed on a continuous moving pallet mould conveyor, the cores are then placed in position and the upper half moulds are added. The complete moulds then travel round to the casting area adjacent to the furnaces. Molten metal is carried from the furnace in pre-heated ladles suspended from an overhead runway and the castings poured.

When the pallet mould conveyor is moving at its normal rate of about 10 ft per minute, the moulds take some 30 minutes to travel through the cooling tunnel seen in Fig. 1. This is sufficient to cool the heaviest castings that the production line is expected to handle. The cooling tunnel is completely enclosed so that the fumes can be extracted from it by fans and taken out of the building.

On leaving the tunnel, the moulds arrive at the knock-out station. This, too, has been enclosed to prevent dust and fumes from spreading into the foundry. Most of the sand from the mould falls through a vibrating grid on to a belt conveyor which returns it to the storage hoppers of the moulding-sand plant. On the way, the used sand passes a magnetic separator to remove particles of iron and a rotary screen to take out any lumps of hard sand. The empty moulding boxes are returned to the moulding machines on a gravity roller conveyor. Although only a little sand is sucked into the exhaust hood, a wet dust extractor is installed to prevent this from being discharged into the atmosphere.

At the knock-out station, the castings are loaded into pallet trucks and the runners, risers and feeder heads broken off with a hand hammer and this material returned to the charging platform for re-melting. The castings go forward to a rotary shot-blasting table for cleaning and are then placed on a turn-table which serves both as an inspection bench and as a temporary storage rack.

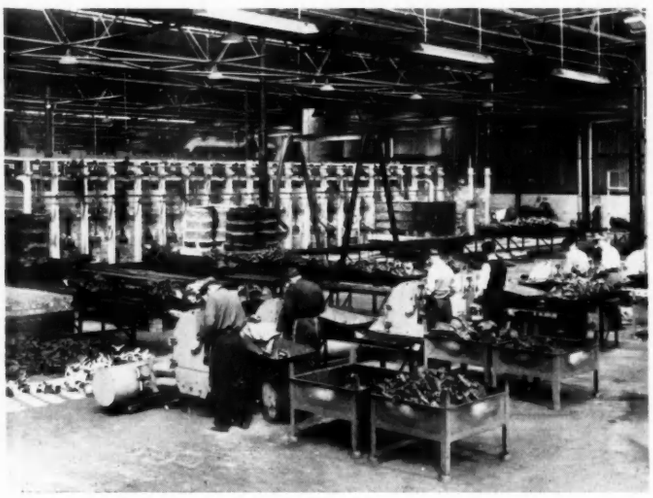
Inspected castings are then packed into covered containers, built up of white-iron rings, which are afterwards sealed by luting to protect their contents from the action of the furnace gases during their passage through a tunnel annealing furnace to convert the white cast iron into blackheart malleable. The containers are mounted on rail trucks, and a loaded truck is pushed into the furnace by a hydraulic ram every 8 hours and a truck load of annealed castings is simultaneously ejected from the other end.

The furnace is oil fired and both the oil and the air supplies are controlled by electrically-operated valves. Four heating zones, including preheating and cooling areas are provided. The maximum malleablising temperature employed is 900 deg. C., and the normal annealing cycle occupies some 5½ days. The annealing furnace, with the entry end on the right, is seen, together with some of the containers, in the background of Fig. 2.

After annealing, the malleable castings are conveyed to a battery of grinding machines, seen in the foreground of Fig. 2, each of which is connected to a wet dust-extraction system, for the removal of gates and flashings. The next operations are pressing, hand straightening and gauging, and the castings are given a second shot-blasting treatment before a final visual inspection and dispatch.

The physical properties of blackheart malleable iron castings render them suitable for a wide range of engineering applications, including such components as wheel hubs, differential housings, brake and other pedals, brake shoes and steering gearboxes for motor vehicles, and various parts for electric motors, clamps and other machines and tools.

Fig. 2 Grinding machines removing gates and flashings from annealed blackheart malleable castings. The tunnel annealing furnace which comprises four heating zones, the maximum temperature being 900 deg. C., is seen in the background. The annealing cycle takes 5½ days.



PROGRESS IN INTERNATIONAL STANDARDS

Frontiers Crossed at ISO Meetings, Harrogate

It fell to the lot of the United Kingdom to be host this year for the triennial ISO—International Organisation for Standardisation—general assembly sessions with concurrent meetings of 15 ISO technical committees. This, the fourth plenary session, was held at Harrogate from 9-21 June. Nearly 1,000 delegates attended from about 35 countries—almost every country which engages in foreign trade. These included about 150 delegates from the United Kingdom, 100 from France, 70 from Germany, 50 from Italy, 60 from the United States, 30 from Russia, as well as representatives from other countries such as Burma, Turkey and Mexico.

Only a few weeks ago, the importance of this country's participation in international standards work had been emphasised at a conference of British engineers responsible for standards (ENGRG., 20 June, p. 798), and the results of the Harrogate meetings were awaited with considerable interest. From the information made available by the British Standards Institution, who organised and provided the services for this conference, the 1958 Harrogate ISO meetings were noteworthy for the measure of agreement reached and the technical progress made in the drafting of international standards. The underlying spirit of co-operation and urge to agree which prevailed throughout the sessions was something unique in international conferences of this kind.

TRADE BARRIERS

The tone of the conference was perhaps set by ISO's President, Sir Roger Duncalfe, in his opening address in the Royal Hall, Harrogate, on Monday, 9 June, when he advised the delegates to "break down the barriers." Sir Roger said that probably we should all agree that a peaceful future for our civilisation and a greater measure of happiness for all mankind depend more upon a steady rate of economic growth and a continuing expansion of world trade than on any other factor. Hence we must break down the barriers to that expansion. He went on to say that "misunderstanding" was one of these barriers. ISO set out to remove "misunderstanding" and to ensure through international standards that as trade spreads about the world—the buyer looking for new sources of supply and the seller for new markets—both buyers and sellers, even though speaking different tongues, work to a standard or specification they both understand.

Typical of the progress made was that of the technical committee on food containers, with Mr. H. A. R. Binney (Director of the British Standards Institution) as chairman. The two draft recommendations agreed by the committee were one for a range of nominal capacities and diameters of tins for milk, and the other laying down a set of 18 ranges of cans for such products as meat, soup, fruit and vegetables. For example, the recommended system is for a number such as "12" to indicate nominal capacity (in this instance 850 ml); the capacity of this can would be never less than 824 or more than 876 ml irrespective of the source of supply. The recommendations may be regarded as an important first step forward in the standardisation, internationally, of food cans. After ten years of striving to reach agreement the committee had at last, in the words of Monsieur Alquier, leader of the French delegation, "crossed the frontier."

SCREW THREADS

An agreement which will be of great benefit to the engineering industries of all countries in facilitating the exchange of goods and services was reached by the technical committee on screw threads. Under the chairmanship of Dr. Hilding Tornebohm (formerly technical director of the Swedish SKF company and Past President of ISO) delegates from 27 countries agreed upon a comprehensive inch series of screw threads from $\frac{1}{16}$ in up to 6 in, and a similar metric series—both based on the standard ISO profile for screw threads which is, in fact, the Unified

Continuing Production

thread profile. The committee will, however, continue to have as as its ultimate objective the bringing of the two series, inch and metric, together into one comprehensive and interchangeable system of screw threads for world-wide use.

Final agreement on a test code was reached in the technical committee on machine tools, meeting under the chairmanship of M. Pierre Salmon (ingénieur général at the Commissariat à la Normalisation, Paris). The value of this code in facilitating exchange of machine tools between one country and another will be extended by the committee's further agreement on ISO recommendations covering lathe centres, tool posts, and speeds and feeds for machine tools.

STEAM-GENERATING PLANT

At the inaugural meeting of the technical committee on methods of testing fuel-using equipment with Mr. W. W. Campbell (Merz and McLellan) in the chair, good progress was made on drafting a test code for steam-generating plant used in power stations. This work is intended to provide an international code on which to base contracts and acceptance tests for large-scale boiler-plant. It will take into account current practice in a number of countries (notably Great Britain, Germany and the United States) and the tests it prescribes will be primarily concerned with the thermal efficiency of boilers.

Timber and metal pallets—used in the unit-load method of materials handling—were dealt with by a technical committee under the chairmanship of Mr. C. Y. Hardie (special services officer, British Road Services). Recommendations for three sizes of through-transit pallets, namely, 32 by 40 in, 32 by 48 in and 40 by 48 in, had already been put forward, and, at Harrogate, the delegates completed the drafting of a recommendation for larger pallets: 48 by 64 in, and 48 by 72 in. Agreement was also reached on the basis for recommendation for testing timber pallets, and on the final amendments to a glossary of terms to be published, in the first place, in English, French and Russian. Equivalent terms in other languages will be added if requested.

The general assembly was also made the occasion of the second meeting of the technical committee on nuclear energy under the chairmanship of Mr. Morehead Patterson (chairman of the American Machine and Foundry Company). There are already three sub-committees in existence and a fourth, to be concerned with radioisotopes, was set up at Harrogate. The sub-committee concerned with terminology, definitions, units and symbols agreed on a tentative first list of 223 concepts which will later be defined in a glossary of nuclear terms—thus enabling scientists and technicians in different countries more easily to exchange information and remove possible misunderstandings in trading practice. Delegates also agreed on the basic design of a symbol to denote the actual or potential presence of ionising radiation.

Another of the sub-committees, the one which is concerned with radiation protection, decided to adopt as a basis for its activities the drawing-up of drafts concerned with the indirect contamination of individuals, and radiation detectors. It planned to co-operate with oth r relevant international bodies. The other sub-committee, which deals with reactor safety, defined the extent of the committee's interest in radiation measurements, health records and effluent discharge, bearing in mind the concern in these subjects of other organisations, namely, the International Commission on Radiological Protection and the International Atomic Energy Agency. The sub-committee agreed that work on potentially critical accumulations of material connected with processes other than reactor operation should also be undertaken at the appropriate time. In planning its future activities the sub-committee foresaw the need to collect and collate the great mass of documentation now becoming available on the subject of reactor safety.

INTERNATIONAL AGREEMENTS ON MATERIALS AND EQUIPMENT

In the interests of easier world trading, the technical committee on light metals and their alloys is seeking agreement on the chemical composition and mechanical testing of aluminium and magnesium, and their alloys. Over the last three years this committee has already prepared recommendations relating to magnesium ingots and magnesium alloy ingots and castings; other recommendations, for pure aluminium, aluminium-alloy castings, and the tensile and hardness testing of light alloys, are also at an advanced stage. Further progress was made at Harrogate under the chairmanship of Mr. J. Duval (technical director, Association Française de Normalisation), when agreement was reached by representatives from 14 countries on standards covering the compositions of magnesium-zirconium alloy castings, four additional aluminium-alloy castings, wrought aluminium and aluminium alloys, and pure magnesium.

Copper and copper alloys formed the subject of another technical committee with Mr. G. Weston (technical director, British Standards Institution) in the chair. Agreement was reached on three proposed ISO recommendations: the first related to methods of test for residual (internal) stresses of copper and copper-base alloys (mercurous nitrate test); the second concerned methods of test for expansion of copper and copper-alloy tubing (pin test); and the third recommendation was on the subject of the classification of raw copper. Progress was also made in drawing up basic classifications for wrought copper and its alloys and cast copper alloys, and in the preparation of a draft specification for electrolytic copper.

On account of the indisposition of Dr. J. G. Pearce (director, British Cast Iron Research Association), the chair of the technical committee on cast iron was taken by Mr. R. McKinstry (BSI technical secretariat). The delegates here brought to virtual completion a recommendation on the tensile testing of grey cast iron which will enable manufacturers and users in any part of the world to compare this material on a uniform basis. Agreement was also reached on a method of testing the hardness. A useful preparatory discussion was held on international standards for malleable cast iron, and spheroidal and nodular-graphite cast iron.

The technical committee on steel, with Mr. E. W. Senior (commercial director, British Iron and Steel Federation) in the chair, agreed on four proposed methods for the high-temperature testing of steel and on various methods for the mechanical testing of steel tubes.

The former will be welcomed by the sections of industry concerned with the production and export of boilers and other equipment operating at temperatures up to 1,000° C, while the latter will be of benefit in structural engineering and the fabrication of pressure vessels. The committee's further programme will include the consideration of international specifications for the materials themselves.

Substantial progress was made by the committee considering the physical and chemical properties of solid mineral fuels (coal and coke), the classification of mica, and standards for materials and apparatus used in cinematography and photography. Many overseas standards bodies now operate certification marks—similar to BSI's "kite-mark" scheme—and the ISO technical committee set up to investigate the practice in different countries agreed at Harrogate on the principles applicable to the operation of these "marks", and also reached general agreement on the broad principles on which informative labelling of products should be based.

ELECTION OF NEW PRESIDENT

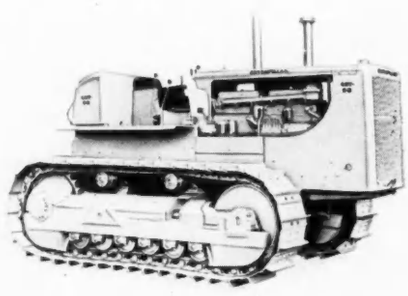
The General Assembly elected Professor E. A. Wegelius (director of Finland's National Research Institute) as ISO's new President. He will succeed Sir Roger Duncalfe at the end of the year. Many delegates during the meetings made a special point of paying tribute to Sir Roger's work over many years, in the interests of standardisation, particularly in the international sphere.

The Council elected Vice-Admiral George F. Hussey (managing director of the American Standards Association) as Vice-President of ISO for a term of three years in succession to Dr. Carlo Rossi (Italy). Dr. Rossi and the treasurer, Mr. W. Ruggaber (Switzerland), who had served for six years, were thanked by the Council for their notable services.

New members of the Council elected by the Assembly were Netherlands and Rumania, the U.S.S.R. being re-elected.

BRITISH-BUILT CATERPILLAR TRACTOR

Fred Myers Limited, Caterpillar tractor dealers for London and south-eastern England, who have just moved into new offices at 24 Bruton Street, Berkeley Square, London, W.1, announce the production of the first British-built Caterpillar D8 tractor. Designed by the Caterpillar Tractor Company, Peoria, U.S.A., the new D8 is now being built at the Glasgow factory of the Caterpillar Company's British subsidiary, and will soon be put into production in the American factory as well. The American and British tractors will be identical, and all parts will be fully interchangeable.



Re-designed, with increased power and ground clearance, the new Caterpillar D8 tractor is now in production at Glasgow, and will soon be built at the American factory as well.

The new D8 is a completely new design, not an adaptation of the American machine, and it incorporates several improvements, including extra horse-power and draw-bar pull. Engine horse-power at the flywheel is now 225 and the draw-bar h.p., at sea level, is 178, compared with the former figures of 191 and 155 respectively. Ground clearance and length of track are increased, and the area of ground contact of the track shoes is also greater. Equipment immediately available for the new D8 includes a rear-mounted, double-drum cable-control unit, and a new angledozer. The Caterpillar No. 463 low-bowl scraper will continue to be supplied for use with the new tractor.

Construction

LARGE ALUMINIUM EXTRUSIONS

Scope for More Economical Designs

One of the advantages of aluminium as a structural material is the wide variety of complicated sectional shapes in which it may be formed by the extrusion process. The term "aluminium," of course, is used collectively for the whole group of high, low and medium strength commercial aluminium alloys used to produce extruded sections.

Because of the high pressures involved in extruding aluminium, it has been necessary to strike a balance between complexity of shape and the overall size of extruded sections, "solids" and "rounds" being easier to extrude than tube, hollow or box sections. Until a few years ago the maximum size of extruded section commercially available in this country was limited for general applications to those sections which could be contained within a circle of 15 in diameter and were of lengths no greater than 65 ft.

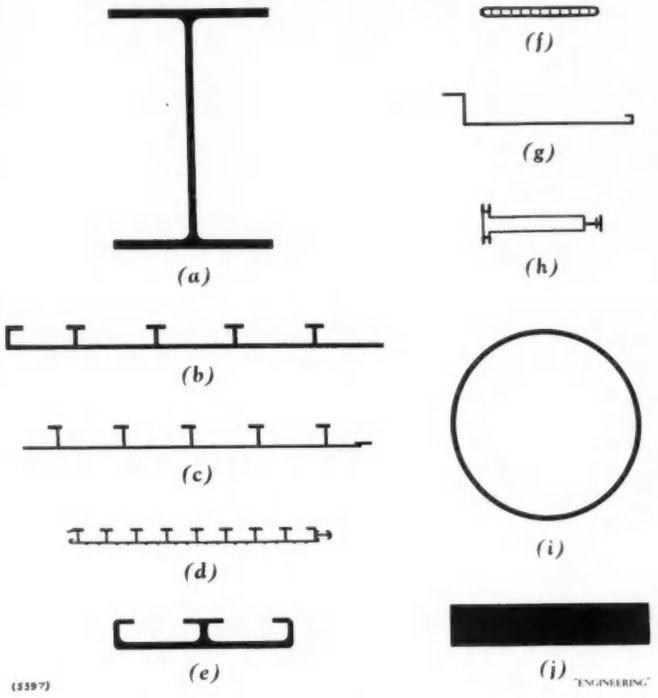
Considerable technical developments are therefore implied in a recent announcement by Harvey Aluminium, Torrance, California, of a larger line of extruded structural aluminium shapes with sections up to 32 in dia and in lengths up to 110 ft. For example sections up to 33 in wide, comparable with wide flange steel beams, are available in heat-treated lengths of up to 80 ft; the aluminium sections weigh 80 lb per foot length as against 240 lb per ft for the comparable steel shapes. The wide flange section with a 24 in web (*a* in the illustration) would formerly have been fabricated from two or more sections but can now be extruded as one section with more uniform strength throughout the member and greater beam stability.

The heavy press installations enable extra wide panel sections to be extruded with stiffeners as integral parts of the sections. A truck trailer door section 38 in wide (*b*) extruded to shape, was formerly fabricated from sheet with separate extruded frame and stiffening members riveted in position. The one-piece extruded panel is stronger, stiffer, and costs less, and as the figure indicates (one door frame section has been omitted on one side), the width can be adjusted as required. A similar type of extrusion, eliminating machining or riveted fabrication costs, is the 35 in wide integrally stiffened panel (*c*) used in aircraft and missile construction. An extruded section, 26 in wide (*d*) is used to construct an emergency landing strip for aircraft.

For ship deck construction, extruded sections have many applications. The 18 in wide section (*e*), previously fabricated in steel, is an interesting example. An aircraft carrier deck panel of unusual design (*f*). With the cooling ducts integrally extruded in the 12 in wide section it would have been impossible to produce it in one piece economically by any other process.

Wide panels and sections contoured to architectural design are used for column and spandrel covers, and as wall panels in curtain wall installations. Typical examples are 19 in wide column and spandrel covers (*g*) and the 12 in wide structural grid section (*h*).

Large diameter tube has many uses for atomic energy, missile and structural purposes. These may be extruded by Harvey Aluminium with an outside diameter of 19 in (*i*) and the company claim that properties, tolerances and cost are more favourable for an extruded tube than for tube made in any other way.



In heavy current electrical installations aluminium bus bars are usually made up to the required length by joining several smaller bars. Large extrusions 20 in wide and 40 ft in length (*j*) reduce fabrication costs.

The large structural sections and panels which can now be made with the heavy extrusion presses installed by Harvey Aluminium, California, considerably increase the potential use of aluminium in construction work of all kinds. Furthermore, it provides increased scope for designing to achieve greater economy in both materials and fabrication costs.

ALUMINIUM ALLOY FOR MOBILE CONCRETE MIXER

A mobile concrete mixer, made of aluminium alloy to give reduced weight and increased payload, has completed two years satisfactory working. Possibly the first of this construction to be used in Great Britain, or indeed anywhere, it has recently been overhauled. To date it has carried over 14,000 cu. yd of concrete. During the overhaul, undertaken by Fredk. Braby and Company, Limited, of Bristol, the fabricators of the aluminium work, it was found that the alloy shell was still in good condition and that the interior had been reduced in thickness due to abrasion by the concrete aggregate by only 0·020 to 0·030 in. The steel mixing blade had been considerably worn, by approximately $\frac{1}{16}$ in all over and in places to a knife-edge.

The use of aluminium alloys for the construction of this concrete mixer has enabled the contractor to obtain a payload of 7 cu. yd against 6 cu. yd with a conventional drum on the same chassis.

The mixer, which is no different in basic design from a standard one, was built in September, 1955, and put into regular service by F. Bowles and Sons, Limited, of Cardiff, early the following year. The drum is approximately 7 ft in diameter and 12 ft long, and weighs 1,500 lb; it was made throughout from $\frac{5}{16}$ in thick Noral B54SM plate with stiffening rings in Noral 54SM bar, bought from Northern Aluminium Company Limited. The plate was argon-arc butt welded both inside and outside and the heavier rings were Argonaut welded on the outside. The interior spiral blade was made from $\frac{1}{16}$ in steel plate bolted to Noral aluminium alloy brackets which were welded to the inside of the drum.

The use of aluminium alloy for the mixing drum, and also for auxiliary items such as the sub-frame, water tank and concrete chute, enabled the payload to be increased from 6 cu. yd to 7 cu. yd compared with a steel drum on the same chassis. The number of journeys necessary has therefore been decreased, with savings in time, labour, fuel and maintenance. Additional savings have been effected by the reduced fuel consumption and wear and tear on the return journeys of the empty mixer.

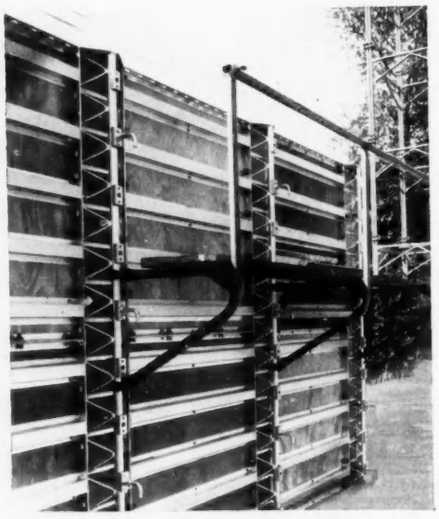
Since the introduction of this mixer in 1955, two others of the same capacity have been put into service by the same contractor. Even where such large capacities are not required, the use of aluminium to reduce the weight of smaller mixers could not only show substantial savings in operating costs but might also enable a smaller, lower-priced chassis to be used in the building of a vehicle to carry the same payload as a mixer embodying conventional equipment.

Continuing **Construction**

WALL SHUTTERS WITH PLYWOOD FACINGS

Plywood formwork, in panels 4 ft wide by up to 5 ft in height, are now available from Kwikform Limited for use with the steel aligners which are their standard support for wall shuttering. The accompanying photograph shows two bays of this shuttering, 10 ft high, and also a convenient working platform which fixes to the back of the vertical alignment. Close inspection of the far bay in the photograph shows the access panel which allows concrete to be placed within the shuttering with a drop that does not exceed 5 ft.

The aligners around which the system is designed are framed steel posts 10 ft high by 1 ft wide which are normally erected in pairs at 5 ft centres. Each aligner of a pair is linked to the other by rod couplers which have become familiar components of the Kwikform system.



Kwikform plywood panels for wall formwork.

The panels then fit between the aligners and are fixed by a quick-release nut and bolt. The new system is designed for use with the company's Mark II steel formwork and a "transfer" aligner is available to correct for the difference in panel thickness between the steel and plywood panels. Damage of the edges of the plywood is prevented by a metal strip. Two men are easily able to handle and quickly fix the 20 sq. ft panels of formwork thereby cutting the heavy cost of labour usually required for shuttering large face work.

In addition to the standard panel 4 ft wide by 5 ft deep, smaller panels 4 ft wide but only 1 ft 8 in, 8 in or 4 in deep are available; together with "timply" filler 2 in, 1½ in or 1 in deep they are sufficient to allow any height of formwork to be made up to within the nearest ½ in.

The equipment was first shown at the recent Ministry of Works building plant exhibition at Birmingham. The head office of the company is at Waterloo Road, Birmingham 25, and the London address is 66 Victoria Street, S.W.1.

Engineering at Home

HEATING AND COOLING THE THERMOELECTRIC WAY

Appliances using thermoelectric refrigeration have been demonstrated by Westinghouse Electric International Company, 40 Wall Street, New York 5, U.S.A. The appliances operate by means of the Peltier effect, i.e., when an electric current is passed across the junction of two dissimilar materials, heating or cooling occurs at the junction. The direction of the current decides whether heat is evolved or absorbed.

Westinghouse state that their new technique requires at least 50 per cent less apparatus than conventional compression methods of refrigeration. Moreover, the thermoelectric method is noise and vibration free, simple to control, and capable of rapid temperature change at the junctions. These advantages were demonstrated in a device that both cools and heats a baby's bottle automatically, and in a mobile hostess trolley with both refrigerator and oven compartments.

The bottle warmer, including its stand and controls, occupies less than half a cubic foot. It contains 50 junctions mounted around an anodised aluminium container furnished with vertical aluminium fins for the dissipation of removed heat. The device incorporates an automatic timing mechanism, in conjunction with thermostatic control, which can be set 12 hours in advance. This allows the appliance to be set to "cool," so maintaining the bottle's contents at 40° F until about 20 minutes before feeding time; then the unit automatically switches to "warm" and in 15 to 20 minutes the bottle's contents reach 100° F and a buzzer sounds.

The hostess unit is an enclosed four-wheel serving trolley. It operates either on regular house current or on its own batteries (utilising house current automatically recharges the batteries). The central portion of the enclosed trolley is a refrigerator with a capacity of 2 cu. ft. The upper section is a 1·3 cu. ft warming oven which maintains a temperature of 150° F. Designed for use either outdoors or indoors, the trolley has the basic function of providing a temporary storage for previously prepared dishes.

Mr. C. J. Witting, consumer products vice-president of the company, has pointed out that the new technique has made it possible to produce new products and he has given instances of some that have been proposed, namely, a combination electric heating and cooling pad or blanket, a refrigerated mixing bowl, a portable refrigerator, photo-developing trays, water coolers, cooled drawers for storing vegetables and other foods, moth-proof drawers and cupboards for furs and woollens, and a combination freezer-cooker.

In a further comment, Mr. Witting has stated that it had not been practical, heretofore, to design small appliances that had a refrigerating function, and this innovation meant an entirely new line of household products which could create a new industry within that industry. Most important these devices represented a new source of "cold" and it could be foreseen in the not too distant future when thermoelectric cooling would replace the conventional air-compressor as a "cold-maker" and remove the need to have one central refrigerator.

TWIN BURNER BOILER

A third model in the range of "Oilheat" domestic oil-fired boilers is to be manufactured by Henry Wilson and Company Limited, Kirkby Trading Estate, Liverpool. The new model 54 has twin burners and is intended to bridge the gap between the company's smaller vapourising domestic boilers, which have outputs between 25,000 and 35,000 B.t.u., and their pressure-jet boiler-burner units, the smallest of which has an output of 80,000 B.t.u.

The "54" shown in the accompanying illustration, is suitable for the medium or large house where domestic hot water and central heating are needed. The unit has an output of 54,000 B.t.u. and burns domestic vapourising oil. When used for space heating alone, it will provide a radiation surface of 330 sq. ft, including unlagged pipes. The boiler is automatic and has thermostatic control. Twin burners give the maximum output, but one burner can be used alone when less heat is required. The maximum fuel consumption, with both burners, is 3·6 pints an hour, the minimum consumption is two-thirds of a pint an hour. With one burner operating, the maximum consumption is 1·8 pints and the minimum, one-third of a pint per hour. The boiler is 2 ft 10 in high (3 ft 4 in when the flue base is included; its depth is 1 ft 6½ in, and its width, 2 ft 9 in).

The new Oilheat boiler has twin burners and is suitable for medium and large houses.

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